THE MONUMENTS OF AMADEO VIII., AND OF EMANUELE FILIBERTO, IN THE ROYAL CHAPEL OF ST. SINDONE, IN MILAN, EXECUTED BY BENEDETTO CACCIATORI, AND POMPEO MARCHESI.

FROM THE ITALIAN OF FELICE ROMANI.

The Royal Chapel of Sindone is a majestic structure, remarkable for its large proportions and its gigantic cupola. The architecture is distinguished by great boldness of design, for the artist departed from the rules that regulated the construction of the ancient temples, trusting his own fancy and taste for a novelty of design. But it was left to our own excellent monarch to adorn it with sculpture, which he has done by the introduction of two new monuments, one sacred to the memory of Amadeo VIII., and the other to Emanuel Filiberto. The one was celebrated for his piety and justice, the other for his valour in war and wisdom in peace.

The monument to Amadeo VIII., by Cacciatori, has been already well described in the public journals, as it was the first finished, and has been several months in the situation assigned to it. I will not repeat the opinions of the critics as to the style of the architectural part, or discuss the propriety of introducing the iconological figures grouped around an historical person. The work of Cacciatori is rather to be considered in reference to its execution, than its conception. It is not,—but the remark applies to all human productions,—exempt from some defects, yet it has so many beauties that the defects may be lost sight of, and are of little consequence.

The group of three figures above the monument is sufficient to show that the artist is quite worthy of his celebrity. The duke is represented leaning with his right hand upon Justice, and extending his left to Happiness. This group is remarkable for the thought embodied in the figures, which are noble and dignified in expression, natural in attitude, and skilfully finished in the outline, drapery, and accessories. The great beauty of this group, and especially the life that is thrown into the three figures, is, perhaps, the reason why the two figures at the foot of the monument, Firmness and Wisdom, appear cold and formal. The basso relievo at the base is considered a useless ornament, as it expresses a thought already and better expressed in the group. The criticism which appears to me most just, is that which has been passed upon the architectural part, for however well it may be designed, and although executed according to the rules of art and from the best models, it is too large in its dimensions, and is wanting in lightness and elegance.

These defects, although of little importance, if indeed they are at all worthy of notice, would be still less deserving of attention if the work of Cacciatori was not opposite the monument of Emanuel Filiberto, the production of Marchesi, which is distinguished by truth and grandeur, as well as harmony in the invention, workmanship, and even in the space which it occupies. A simplicity and unity of conception is the great merit of this monument—a merit anxiously sought in every work of imagination by the ancients, but greatly neglected by the moderns. Upon a light and elegant base is raised the figure of Emanuel Filiberto, completely dressed in armour. He stands in a majestic attitude, with his sword in his right hand, the point turned to the ground, and with the sheath in his left. Decision sits on his brow—he stands with an air of noble severity: he is the hero who has gained the battle of St. Quintino, and looking with security around him, he finds himself master of the field, and puts down his conquering sword conscious of a complete victory. On his face there is still the glow of that warlike fire which not long before was burning; but on his forehead appears the first thought of peace, and on his lip is a smile of complacency and of faith in his fortune. One might believe, that after a moment of repose he was about to step forward, and turn to discover if there were more enemies to conquer—one might expect to hear from his lips the order to cease the pursuit, and an assurance of victory. So much life is there in his face, so much truth and expression in his attitude, that art seems to have perfectly overcome the impediments thrown in her path by nature. But this figure has another merit rarely obtained in a statue dressed in armour, instead of a flowing drapery with its beautiful folds. A figure in armour must have some angular parts, which detract from the elegance of the form; but the armed statue of Emanuel Filiberto, from the chisel of Marchesi, has not this fault—the iron garments are so carved as not to detract from the beautiful proportion of the limbs of the noble warrior.

At the foot of the hero are placed two very handsome female figures, History and Munificence, accompanied by their proper emblems, which clearly distinguish them. They fully represent the conceptions of the artist, and are so evidently connected with the hero above them, that one might at first doubt whether they are the emblems of the heroic character, or the hero their personification. Munificence is in the attitude of dictating the exploits of the valiant, and History is writing them. The former has by her side the lion and the owl, the one a symbol of strength, the other of wisdom, an attribute without which munificence must fail to perform her desire: the second is winged like Fame, for History is but another name for Fame herself, and although she has not the trumpet that stuns the air, she has the tool that engraves characters which cannot be erased. Neither the thought of the poet, nor the hand of the artist, could produce a more elegant figure, a more dignified person, than the sculptor has produced in this representation of History. She is of surprising beauty in form, in grace, in carriage; and of wonderful effect in the truth of her attitude, position, and expression. You would be tempted to ask her what she was writing; you would be on the point of saying to her—In the midst of the memorials of the deceased hero, among the great works of the magnanimous prince, who is living to bless us, and of whom Munificence dictates to you the generous thought, preserve, oh God of eternal memory, in some of thy immortal pages, preserve a little space to cut the modest name of an artist; since the arts had the same celestial origin as thyself, and co-operate to the glory and spendour of nations, write, O History, the name of the sculptor who created this image of thy beauty—write the name of Pompeo Marchesi.

DESIGN FOR A COVERED MARKET PROPOSED TO BE ERECTED AT DONCASTER.

BY W. HURST, ESQ., ARCHITECT.

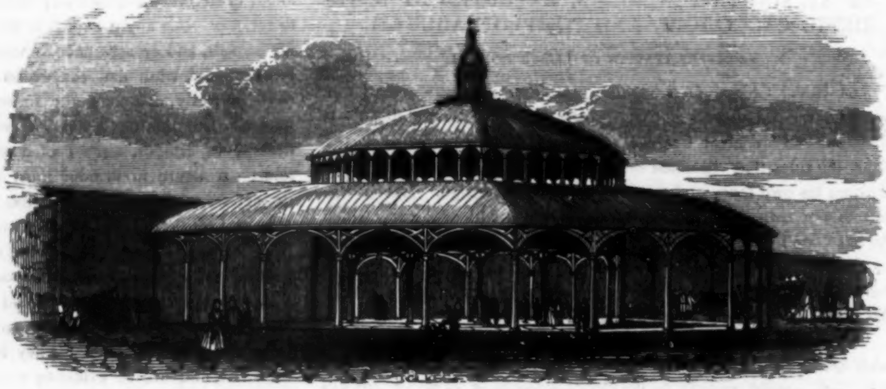
Mr. Hurst has given the following description of his design for a market at Doncaster, which seems to us admirably suited for the purpose required, and so designed that it may be executed at an exceedingly small cost.

"The plan is intended to occupy the site of the present market, to be one hundred and twenty feet from east to west, and ninety feet from north to south, covered with a corrugated wrought iron roof.

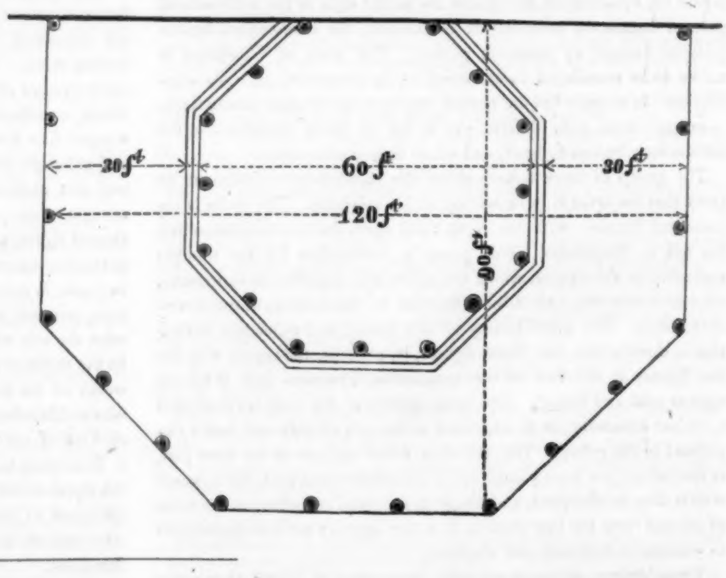
The eastern and western angles are to be taken off parallel to the interior octagon, which is to be sixty feet in diameter, so that the whole area covered by the roof will be eleven hundred yards, which

will not be more accommodation than the increasing corn markets require.

The whole of the roofs are supported upon twenty-seven metal pillars, twenty-one feet high, seven inches in diameter, with a four-inch core; the space under the centre octagon to be lighted by an open lantern ten feet above the lower roof, and extending all round the inner octagon, making the centre of the building nearly as light as in the open air.



This form of structure, it is presumed, will be best adapted to the situation, not infringing too much on the present market, offering less obstruction to the houses east of the building, and allowing better access to the parsonage yard or cattle market.



The business within the area of the corn market will be carried on in exactly the same manner as if the space were not covered, the whole area being sufficiently spacious to allow the centre part to be raised two or three steps, and used as an open bourse or exchange, as in commercial towns, independent of the part where the corn is pitched.

The erection will also form a skeleton easily fitted up at a trifling expense, to hold public meetings, or give entertainments on public occasions to upwards of a thousand persons, the tables being so managed that the speakers will be distinctly heard in every part of the edifice.

I have ascertained from the estimates of practical iron workers and founders, that this erection may be made and finished according to this plan, in a light and substantial manner, for a trifle more than one thousand pounds."

HOW TO OBSERVE GOTHIC ARCHITECTURE.

(*Continued from page* 162.)

F, The Portals.—In the primitive churches there was but one entrance leading into the *Atrium*. This entrance is now represented by the great door, which generally looks towards the west; but is sometimes, as well as the porch, carried back to the bottom of one of the collateral naves.

Besides the principal portal, a part of the edifice on which the arts of the middle ages have often lavished all their magnificence, it is seldom we do not meet with others, and particularly on the interior face of the transepts. These entrances to the church, bearing a very important relation to the enrichment of the building, should be described with great care and attention to details, and the observer ought to ascertain whether they form part of the general plan of the church, or whether they have been posterior to it, or anterior, for the latter is sometimes the case.

G, The Porch.—The porch is that portion of the edifice, commonly exterior, which was destined, according to the rites of the Primitive Church, to shelter from the weather, but more especially from the assembly of the faithful, the catechumens and the penitents. These rites having been abandoned for many centuries, their suppression has superseded more or less, according to the localities, the distributions which corresponded to them. The presence of the porch is generally a sign of antiquity and fidelity to the Primitive liturgy; and it should be noticed and described with particular attention, whenever it has been constructed with this intention. But we must carefully distinguish this normal porch from the different constructions, exterior as well as interior, which have been confounded with it under the same denomination, namely, first—

In the interior, the porch in form of a cupola, in imitation of the Holy Sepulchre, placed at the entrance of some of our Roman churches. The accidental porch formed by the base of a steeple placed

upon the middle of the portal, or the contraction produced in the plan of this same portal, by the bases of two lateral steeples.

On the exterior—the peristyle porch, an imitation as complete as its constructors could make it, of the antique peristyle, not only in its mass, but also in its minute details of disposition and ornament. We find in some places traces of the employment of curtains, for the purpose of protecting the worshippers from the sun and rain.

The tribunal-porch, commonly supported on two pillars, in the decoration of which figures of lions are almost always introduced.

It is well known, that in the middle ages justice was often administered at the gates of churches, and that certain acts of authentication were performed there. Sometimes this tribunal-porch, instead of being supported upon the portal, is supported upon the religious porch, and then constitutes a regular advanced porch.

The military porch, constructed in front of the portal, to defend the entry thereto in case of need, is generally surmounted with machicollations or battlements. It is sometimes reduced, according to the example of the oriental *moucharabis*, to a mere projection of the upper part, supported by machicollations.

The porch of decoration was often very richly ornamented, and very projecting. It was added to the front of the principal portal, or even some of the side portals, simply with the view of enrichment, generally after the building had been finished, and at a more recent date, when the tradition of the primitive porch has been long lost.

We may lastly mention the *porche au vent*, a light construction placed in front of one of the entries to the church, for the purposes of protecting it against atmospheric influences.

We often find upon the borders of the Rhine, and more rarely in France, churches in which the porch is replaced by one or three absides. In the latter case, the two lateral absides generally serve for a passage. The principal is sometimes occupied by an altar for occasional service, sometimes by a choir of choristers, but more generally by the baptismal font.

We know that the baptistery, which in primitive times was first placed in the middle of the *atrium* or court, was carried back, at the time of the suppression of this *atrium*, into the interior of the church, where it has occupied different places, more commonly on the left, and has taken many forms, sometimes even that of a smaller edifice completely comprehended in the larger.

H, The Bell Towers, or Steeples.—The bell towers, the destination of which is sufficiently indicated by the name, were additions made by Christianity to the plan of the Roman basilica, and were used to place the instruments by means of which was introduced, at a very early age, the practice of summoning the faithful to divine worship. The most ancient ones now known are round towers, isolated from the church, as, indeed, they are still placed in Italy, and not unfrequently in France. These bell towers, or steeples, also served, at the same time, another purpose,—that of pointing out, from a distance, the situation of the church to the traveller. It was for the purpose of performing this last service effectually, as well as from motives of decoration and magnificence, that they have been sometimes carried up to great elevations. In the more ancient churches of France, the principal steeple commonly surmounts the centre of the edifice, at the junction of the nave, the transepts, and the choir.

In cathedrals and abbey churches, there are sometimes seven or eight steeples, but more commonly three, namely, a principal one in the centre of the cross, and two secondary ones on either side of the grand portal. These remind us, by their position, and often by the inferiority of their proportions, of the small bell turrets by which the exterior façade of the *atrium* was flanked in primitive times.

I, The Sacristy.—The sacristy, the use of which, and its common position near the choir, is known to every body, is less an integral part than a dependency of the edifice, almost always added afterwards to the Roman and Gothic churches, and of less importance for its peculiar decoration than for its uses. We mention it here, however, as it is at least an indispensible accessory, and its existence dates from the primitive church, as we have already observed.

CHAPTER II.—THE EXTERIOR OF A GOTHIC CHURCH.

When an antiquary or student commences his examination of the exterior of a Gothic church, he should particularly notice the materials of which the building is constructed, and the manner in which they are united, and record any instance of peculiarity, distinguishing a part from the entire mass.

He should next observe whether the walls are quite plain on their exterior surface, or whether they are decorated with some running ornament, such as vertical or horizontal *striæ* or lattice work, and whether there are any projections or mouldings, or if so, whether they are characteristic of a period in art.

The exterior of an ancient church is sometimes decorated with columns, round or square, attached or disengaged. The observer will find it necessary to describe their situation and form, their base and capital, how they are supported, and what they support. The arcade may consist of arches which intersect each other, a certain proof of great antiquity—or they may spring, variously formed, from columns which, by their capitals and bases, are at once recognised to belong to the same period as the arches they support, or to an earlier or later. The archivault may be plain, with a square edge, or it may be more or less richly ornamented with mouldings; sometimes it is distinguished by several bold projections, like advancing concentric arches. The manner in which the arcade is supported, will exhibit alike the state of art and of the science of construction. Sometimes the archivault is supported by brackets or corbels. Secondary arcades are occasionally found within a principal, similar or differing, as the taste of the artist has directed. Above the central column of these is generally found an oval or circular opening to give light; and in the early examples with three or four divisions, which is the origin of the quaterfoil and trefoil.

A column is that which has a base, shaft, and capital; if either of these be wanting in a construction intended either to support, or to give appearance of a support to a superior mass, it is a pillar, pier, or pilaster. There is, however, an intermediate construction, that in which the shaft is surmounted by an abacus, the superior or upper member of a capital. It is found in almost every variety of Gothic architecture, and in fact so commonly, that it may almost be said there is no Gothic construction in which there is a shaft which is not a column if it have a base. But that is not a column which is wanting in either a base or capital. Pilasters, or square-faced, engaged masses with a capital and base, are unknown in Gothic architecture. Although the Gothic column is not reduced to the certain proportions of the Grecian, it is always desirable to measure the diameter and height of the shaft, and to determine the proportions, forms, and combinations of the other parts.

In certain parts of France, Italy, and other countries where ancient architecture was never entirely lost, the Corinthian column, more or less accurately reproduced by the architects of the middle ages, is constantly found. But instead of following some classical type, they studied an inferior example erected in their own locality or neighbourhood, and in this manner distinguished from each other by peculiar and characteristic features.

The capital of the middle ages almost always consists of a basket and an abacus, and at once brings to our minds more or less strongly the Corinthian order of ancient architecture.

(*To be continued.*)

THE CASTLE OF LA MOTHE ST. HERAYE,

DEPARTEMENT DES DEUX-SEVRES.

The estate of La Mothe St. Heraye, which was last in the possession of Marshal Count Lobau, and which, in default of male heirs, has just reverted to the state, is claimed as their ancient patrimony by the heirs of the late king of Naples, Murat. This claim may give rise to a long course of litigation and doubtful possession. During this period, the administration of domains, which is now actually in possession, will refrain from all unnecessary expenses, and confine itself to those which are absolutely necessary for its management, and the return of the rents, which amount to nearly thirty thousand francs a year.

The castle on this estate, although now untenanted, appears, from a visit we have lately made to it, to deserve some notice. We proceed in few words to give the result of our observations.

This castle occupies the eastern extremity of the town to which it gives its name. The entry to it is by a large court yard, surrounded on the north, the west, and the south, by the offices of the establishment, the exterior walls of which rise from moats, the water in which, well stored with fish, is derived from the Sevre Niortaise, and whose eastern side, entirely open, communicates with the mansion by a bridge.

This habitation surrounds a central court; it is a nearly regular polygon of thirteen sides, one of which is occupied by the Keep, and every third one besides by round towers, between which are square towers.

These last are of a date evidently later than the rest of the edifice; this is indicated by their style, as well as their interior arrangement. The main building, in spite of the indications which might be drawn from some parts, especially the entrance gate, is as old as the time of Henry II.; and the Keep, to judge by its form, and from some indications drawn from its mode of construction, must be yet more ancient, and belong to the end of the 15th century.

The different parts of the interior verify these successive epochs; they are full of interest, and worthy of remark with regard to the arts: we may notice, in this respect, first, the carpentry of the Keep, which is most beautifully constructed; secondly, the Great Hall, the Chamber of Honour, and the Chamber of the Judge, decorated in the style of the Renaissance, with richly carved ceilings, most splendidly gilt, sculptured chimney pieces, and remarkable paintings on stone, which, although injured by damp, are still valuable, and might be restored. The walls of these three apartments are hung with superb tapestries, representing subjects drawn from the New Testament. Thirdly, the Chapel, of the same date, in which are some pictures, four of which are painted on the walls in the compartments of the choir, representing histories from the Old and New Testament, separated by borders bearing the gilt cipher of Diana and Henry II., with delicious figures of cherubs, and baskets of flowers and prints, charmingly executed. Fourthly, the Gilded Chamber, more modern, which, as its name imports, has received, with the two closets appertaining to it, an extraordinary richness of decoration; the ceilings are in compartments, with rich cornices, and gilt masses of detached garlands, receiving beautiful stuffs, of which the largest, in the alcove, represents Juno in her car drawn by peacocks. Fifthly, a number of portraits of various times, and all possessing merit, scattered through different rooms, and of great interest in this branch of art.

Every thing about this residence shows that Count Lobau attached more importance to the rents of the estate than the building itself, and, attaching little importance to the works of art it contained, contented himself with keeping the roof wind and water-tight. The stone work, however, is in general in a good state, some parts only being slightly injured by frost and parasitical plants; the carpentry, and especially that of the Keep, which is the most ancient, is in a good state. But all the exterior shutters, windows, doors, almost without exception, are in an extreme state of dilapidation, or rather no longer exist. Thus the rain, driven by the wind through these broad openings, inundates all the interiors, which do not get dry till the rays of the summer sun come in their turn to contribute to the destruction of the colours and the carved work.

It is said that the marshal intended to have taken steps to prevent this destruction: it is yet time to accomplish this, and not a moment should be lost in commencing the necessary operations, which if done at once might be performed at most for 5000 francs, and thus save from destruction a property upon which artistical considerations confer a high value.

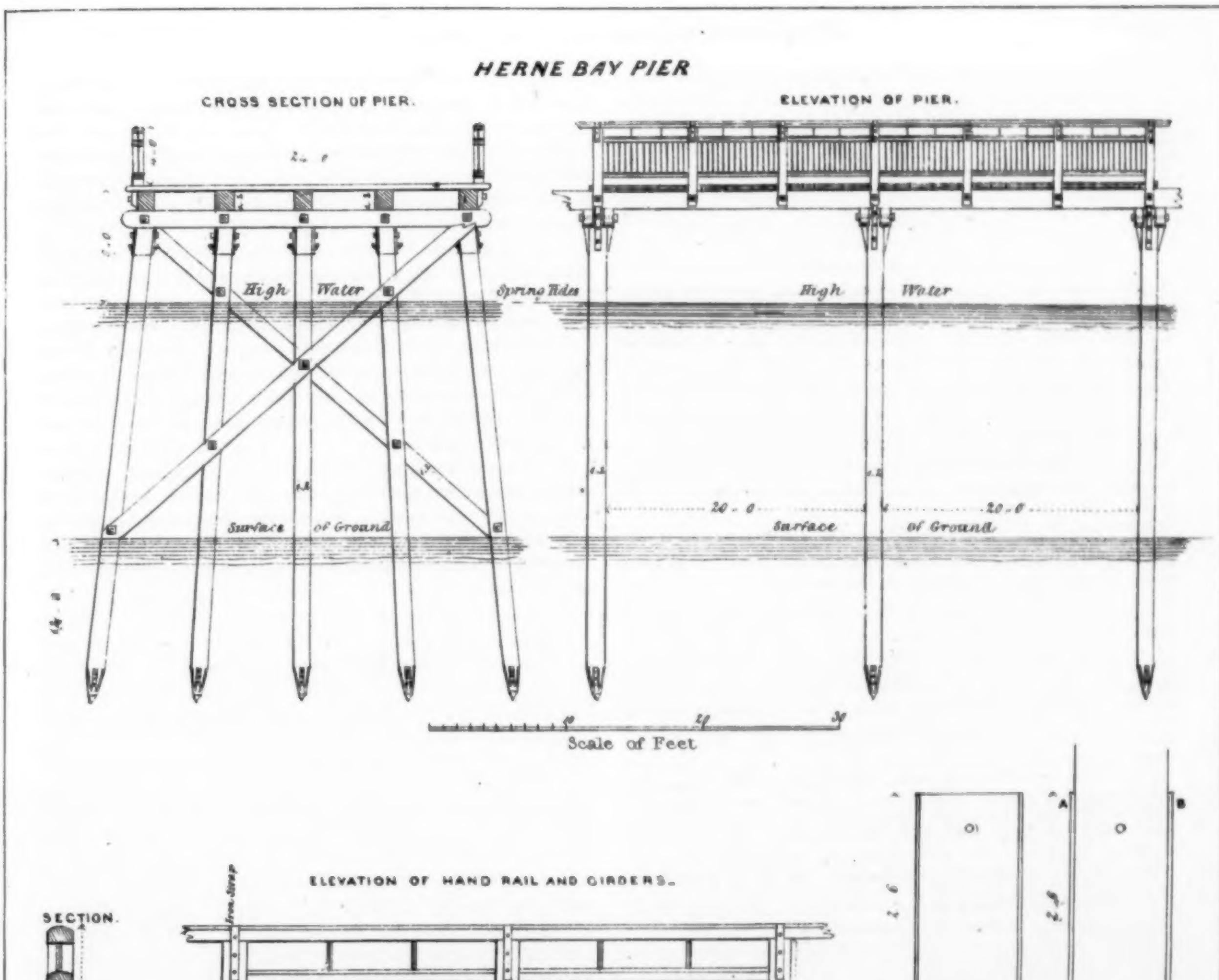
THE HERNE BAY PIER.

A REPORT TO THE DIRECTORS OF THE HERNE BAY PIER COMPANY ON THE PROGRESS OF THE WORKS. BY W. M. HIGGINS, ESQ., SURVEYOR TO THE COMPANY.

Gentlemen,

The works having been closed for the season, for the convenience of visitors, I beg now to call your attention to the present state of the pier compared with its condition at the time when you undertook its restoration. The task you intrusted to me was one which you, as well as myself, knew to be attended with some danger and much anxiety. The peculiarity of the construction of the pier—its dangerous state from the ravages of the worm upon the piles—and the impossibility of making a rapid progress with the work during a winter that was unusually boisterous, made large demands upon patient and incessant exertion. Had it been possible to have closed the pier for a few months the difficulties would have been much diminished, but from the commencement of the repairs the traffic has not been stopped for a single day. That there would be occasionally some impediments, and a few minutes delay in the passage of carriages and trucks, from the disturbance of the platform, was expected; but there is, perhaps, no instance in which a structure of such extent, and in such imminent danger, has been restored without a complete suspension of traffic, and a large, if not entire loss of the established trade. It must, therefore, be highly satisfactory to you that your income, instead of diminishing, or ceasing altogether, has increased during the past year, in a ratio superior to that of the average of former years.

The first pile of this pier was driven on the 4th of July, 1831, and on the 12th of May, 1832, it was opened to the public. The design was furnished by the late Mr. Telford, but the execution was entrusted to Mr. Rhodes. The latter gentleman, however, having received, soon after the commencement of the work, an appointment as Engineer to the Shannon Improvement Commission, Mr. Abernethy was elected resident engineer, and under his superintendence a large portion of the pier was constructed.


HERNE BAY PIER
CROSS SECTION OF PIER.
ELEVATION OF PIER.
High Water
Spring Tides
High Water
Surface of Ground
Surface of Ground
Scale of Feet
ELEVATION OF HAND RAIL AND GIRDERS.
SECTION.
Pile
Scale of Feet.
ELEVATION OF CAST IRON PILE.
SECTION OF CAST IRON PILE.
PLAN A.B.
C IRON PLATE TO PREVENT THE TIMBER FROM CRUSHING
PLAN E.F.
PLAN C.D.
W. M. Higgins, C.E
T. Faulkner, lith.

The pier is 3613 feet long, with a platform 24 feet wide. It consists of one hundred and seventy one bays, exclusive of the pier head, and these are 20 feet apart. One hundred and forty nine bays from the shore seaward have five piles each, the remaining bays have only four piles each. This fact is, of course, sufficient to prove that four-pile bays would have been sufficient in any part of the pier, for as they give the necessary strength where the sea has the greatest power over the structure, more are not any where required.

The pier is of simple construction, and as one of the first structures of the kind in England, must be considered in design a remarkably perfect work, although the restoration would have been greatly facilitated by some variations in the original formation, and especially in the mode of scarfing the longitudinal pieces. By reference to the drawings which I have presented to the Board, there will be little difficulty in understanding the construction, and your acquaintance with the pier will make it unnecessary that I should do more than mention the several parts, and the manner in which they are connected together. The piles in each bay are connected under the longitudinal pieces by two transverse half timbers, called walings, one on each side. The longitudinal pieces are laid over the piles, and attached to them by a mortice, but their principal connection is by a wrought-iron strap or king bolt. In that part of the pier near shore the longitudinal timbers are united by a properly formed scarf, but in the larger portion of the structure a straight scarf or halving has been adopted. These scarfs being brought immediately over the piles, and secured by the iron straps, were not objectionable in the original construction, but were the causes of much difficulty and inconvenience in the restorations which I have performed under your orders, compelling me to reject many plans by which I could have decreased the labour and facilitated the execution of the work. This is, perhaps, all that is necessary to be said upon the construction of the pier, and I will add but a few remarks upon the piles, the destruction of which by the sea worm has been the only cause that has given a necessity for the restorations in which you have been recently so anxiously engaged. The piles were driven to various depths, from ten to nineteen feet. The only principle that was adopted appears to have been, to drive as long as it was possible to force the timber into the ground. In consequence of this many of the piles were split, and some of them so much, that it was thought necessary at the time to drive other piles by their side. But with all the anxiety to obtain strength and durability, evident in every part of the structure, no attempt was made to preserve the timber from the worm. The desire to secure strength, and to resist the force of the sea, an enemy whose power in that situation was then unknown, is especially shown in the adoption of five-pile bays, by which a large and unnecessary expence was incurred, as it involved an increase of one-fifth the whole amount of timber in the longitudinal pieces as well as in the piles. The same motive induced those who directed the original construction, to drive the piles so deeply into the ground. It is indeed strange that, with all these precautions to give stability to the pier, the piles should have been driven without the slightest effort to prevent the attack of the sea worms, which were known not only to cause the rapid destruction of timber, but also to abound on that coast. At Margate on the east, and at Sheppy on the west, there was evidence enough of the existence of the *Teredo navalis* upon the coast, and the fossil woods found in such large quantities in the London clay of Sheppy prove that even at the remote period when that vast bed was deposited, the teredo existed in the sea, and attacked wood in the same manner as in our own day. There was, however, a notion among some persons that this worm was not to be found in coasts with a sandy bottom, and upon this opinion the entire structure of the pier was ventured, but, as you too well know, it has been proved false—the worms have attacked and destroyed the piles, and produced the necessity for that restoration which you were pleased to intrust to my care.

Within six years after the completion of the pier it was pronounced to be in an unsafe state, and in April, 1839, Mr. Coe, a respected Director at that and much at the present time, was requested to obtain the opinion of his friend, Mr. James M'Intosh, upon the real condition of the work, and the manner in which it could be restored. The following extract from the Report made to the Board by Mr. Coe, on the 3rd of May, will show the rapidity with which the destruction of the piles by the worms had proceeded, and the dangerous state of the pier.

"In consequence of the representations which have from time to time been made of the insecure state of the Herne Bay pier, arising from the ravages of the worm, and of the desire of the Committee that I should obtain the opinion of some gentlemen upon whose judgment I could rely, as to the actual state of the same, I requested the favour of Mr. J. M'Intosh, a friend of mine, who is practically acquainted with structures of this nature, and who has superintended the repair of works similarly affected, to inspect the pier for the purpose of ascertaining how far it had become injured by the worm, and of suggesting the least expensive, and at the same time an effectual mode of rendering the pier secure. I strongly urged upon Mr. M'Intosh the necessity of an early inspection, and stated that he would personally oblige me by his immediate attention to the subject. He, in consequence, visited the Bay on Saturday the 27th ultimo, the tide being on that and the following day favourable to an examination of the piles. He wrote to me on his return to town, on the 29th, expressing a desire to see me early the next day. I waited upon him accordingly, and I regret to have to report that his communication to me, relative to the state of the pier, is, to say the least of it, rather of an alarming character, and such as in my opinion demands the immediate and serious attention of the Committee.

Mr. M'Intosh informs me, that on his arrival at the Bay he proceeded to examine the pier, and that he found the same in a very defective state, so much so that he considers it unsafe for passengers passing to and fro,—that several of the bearing-piles are hanging to the superstructure, instead of supporting it, and that others are fast approaching to the same state; that some of the piles, the original dimensions of which were 12, 13, 14 and 15 inches, are now reduced to 9, 8, 7, 6, and 5 inches, which is sufficient to convince him that the pier cannot stand long in its present state, and he therefore strongly recommends that no time should be lost in commencing such repairs as may be necessary to secure the property, and prevent loss of life, and suggests that for *present security* new piles properly scupper-nailed should be driven at about every third bay, on each side, commencing at that part of the pier where the piles are most defective, and braced to such other piles as may be considered sufficiently sound to be useful, taking care that the braces are scupper-nailed, if so situated as to be liable to be affected by the worm. That then piles should be driven on each side at every bay, and that when the pier is thus rendered secure, measures should be adopted for repairing and strengthening such of the internal piles as are most defective."

In October of the same year, a proposition was made to shorten the pier, and to completely restore the remaining part, and another plan, entertained at the same time, was to reconstruct the pier upon Mr. Dredge's principle of suspension. None of these plans, however, were adopted, and in fact nothing was permanently done; but forty-two piles, usually called the "crutch piles," were driven to give a temporary support to the pier.

In August, 1841, a little more than two years after Mr. M'Intosh had delivered his Report, I received instructions from the Directors to make a survey of the pier, and to state my opinion as to the mode in which the necessary restoration could be best effected. At the close of the same month I delivered the following Report:—

Having received instructions from the Directors of the Herne Bay Pier Company to make a survey of the pier, and the works connected therewith, I took an early opportunity of visiting the works for that purpose.

That I may place the result of my survey before the Directors in a manner which shall enable them to judge of the expediency and necessity of that course of proceeding which I have thought it necessary to recommend, I shall first describe the present condition of the pier and the works connected with it, and then state my opinions as to the mode by which the former may be sustained and repaired, and the whole be brought into a condition at once productive to the company and safe to the public.

All the piles from the toll-houses to the pier head are more or less eaten by the worm; but as some are in a much worse state than others, and some absolutely destroyed, it will be desirable to consider the pier as consisting of four parts: that from the toll-houses to the first stairs; that from the second stairs to the end of the Incline; and lastly, the pier-head.

1. From the toll houses to the first stairs the piles are much less injured by the teredo, and the tide, than in any other part of the fabric. Towards the shore the piles are sound, and many of them almost untouched, but seaward they become worse, and near the first stairs there are several bays which require restoration. This is without doubt the strongest part of the pier, and may be kept in a sound state by the adoption of some simple mode of preservation. There are in this part forty-two bays and five piles in each bay, making 210 piles.

2. From the first to the second stairs almost all the piles are much injured by the worm and the tide, many of them being between the ground-line and neap tide high-water mark not more than five or six inches in diameter. There are in this part of the pier forty-five bays and five piles in each bay, making together 225 piles. I consider this portion of the structure to be in a decidedly dangerous state, and although it may be strong enough for a year or two, from the connection of the parts, and the mutual support which one part gives to another, to resist the effect of even a storm from the north-east or north-west, I doubt whether it would resist the power of a body of ice brought in shore from either of these quarters.

3. From the second stairs to the Incline there are sixty-six bays, of which sixty-two have five piles in each bay, but four of these bays have only four piles in each bay, making in total 326 piles. All of these are old piles, and in even a worse state than those on the shore side of the second stairs.

From the beginning of the Incline to the pier-head there are eighteen bays with four piles in each bay, making together, including the pile which supports the end of the incline, 73 piles.

From the middle stairs to the head of the pier forty-two piles have been driven, half on each side, connected by double walings. These have no doubt preserved this portion of the pier from immediate destruction, but I regret to add that none of these piles have been nailed, nor has any provision been made to prevent the attack of the worm, not even a coat of tar, although they have all been driven during the last twelve months. The tide did not run out sufficiently during my stay at the bay to enable me to see the extent of the mischief in this part of the pier; but if it be true, and I have no doubt of the accuracy of the statement, that many of the piles, as seen during the lowest tides, are not thicker than a man's wrist, and some of them absolutely broken, I fear that we must pronounce this part of the pier, although something has been done to sustain it, to be still in a dangerous state.

4. In the pier head there are ninety-one piles, including the four driven this summer, which have been nailed. All the old piles are much injured by the worm; and from the unequal vibration when it is struck by a vessel, I have little doubt that several of them are broken, and hang as a dead weight upon the superstructure.

The Incline.—To strengthen the Incline eight timber piles have been driven, some of which have been nailed, and four cast-iron piles, three of which are plates, about ten inches wide and three inches in thickness, and are driven about seven feet into the ground by the side of the old timber piles, to which they are bolted by three $1\frac{1}{4}$ inch iron bolts with nuts.

Iron Piles.—Two other iron plank piles have been driven between the first and middle stairs, and are attached in the manner already described. Between the middle stairs and the shore end of the Incline there is an iron socket pile which was introduced in place of a timber one destroyed by the worm and broken away.

Platform.—Although of secondary importance, it may be desirable to state, that the planking which forms the platform is in many parts bad on the weather face; and much of that which appears good on the exposed surface was found upon examination to be rotten.

From these statements it will be evident that some effective and well-arranged scheme must now be adopted for the repair and preservation of the pier; but it will be desirable, before proposing any plan, to ascertain the causes which have brought it, within the short space of ten years, into a state which threatens a rapid destruction, if means be not immediately taken to prevent that result. The use of timber without any precaution against the attacks of the worm must be considered as the main cause of the present condition of the pier, and with this fact so evidently written upon every portion of the original work, it is singular that repairs should have been carried on with the same want of common precaution. Various methods of preserving wood have been lately proposed, some of which have received the sanction of the government, and are strongly recommended by architects and engineers. None of these have been tried at the pier. Experiments should have been made long since, and even now, although delayed until it can be of no present benefit, I would recommend that one or two piles, prepared according to the various methods that have been proposed to preserve timber, should be driven in situations where they will be much exposed to the worm, but may be easily removed in case of failure, without detriment to other parts of the work.

But although the present state of the pier is to be traced to the want of precaution at the time of its erection, and the use of unprepared timber, its destruction has been facilitated by a subsequent neglect. Many of the piles have never been touched either with a scraper or a brush since they were first driven, but the worm has feasted upon them undisturbed, increasing in number with a proportionate power of destruction. Whatever plan, therefore, the Directors may adopt, an order should be immediately given for cleasing and tarring those piles which have been recently driven, and some means of preservation should be diligently pursued in future.

It may be necessary that I should made one remark upon the expensive mode of protecting the wood by scupper nails. Whether this plan can, under all circumstances, be depended on for a long period of time, we have no means of deciding, but my own opinion is, so far as I can judge from the instances which have come under my notice, that no plan can be more safely recommended, and I place some dependence on the persevering use of the purified mineral tar.

From the description which I have given of the present condition of the pier, it will be evident that a large portion of it must be ultimately rebuilt, but there is no necessity for immediately undertaking all the restorations which are required, if the Directors will at once put the pier into a state which shall prevent the possibility of immediate injury. This being done, the whole of the work may be restored in four or five years without delaying the advantage which would in every way result to the Company by declaring a dividend, however small. Two modes of executing the work are open to the Directors; one is to employ their own workmen, and the other to obtain contracts. If the former be adopted, an active, intelligent, and practical foreman of works is indispensable; if the latter, a carefully-prepared specification.

I have next to draw your attention to the works, which appear to me absolutely necessary for the present security of the pier.

All the sound timbers should be scraped, cleansed, charred and tarred. The introduction of a few piles on the shore side of the stairs will be all that is there required for the present.

In those parts of the pier which are least injured an ingenious mode of protecting the piles from the worm, by a casing, has been adopted. An oak case $1\frac{1}{2}$ inch in thickness is driven securely into the ground round the decayed pile. The space between the casing and the pile is then filled in with a hard bituminous cement. Simply considered as a defence from the further ravages of the sea worms, this is no doubt effective, and offers a ready means of repairing the piles between the toll-houses and the first stairs, or even a few bays beyond, where the destruction of the piles has not been carried too far for its adoption. Should the Directors feel satisfied with the limited adoption of this plan, than which no better perhaps can be recommended, although, as an experiment, a doubt hangs over it, no time should be lost in casing all those piles which can be thus restored.

In that part of the pier between the first and second stairs, it would be desirable to drive every third or fourth bay entirely new, for no new work has been there introduced, and I consider it now in an unsafe state. In doing this, the present waling, which is sound, might be again employed, and the sound timber, of which there will be a large quantity, will realize a considerable sum by sale, or may be made available for other of the Company's works. The difficulty which is to be met in this and in all the other projected new works is in the scarfs, which are in fact supported by the piles. These, however, may be secured, in the event of removing the present bays.

Between the second stairs and pier-head, every sixth bay should be new. The whole of this part of the pier must in fact be ultimately rebuilt. The new piles already driven, are in two pile bays at a distance of 100 feet, from the second stairs, to about 120 feet from the incline; and from that part to the head of the pier about sixty feet apart. But although the pier is here barely safe, the introduction of so many new piles has greatly added to its strength.

The pier-head requires for its support and safety several new piles, and

it is especially necessary that the centre four-piled bay, which receives all the cross strains, should be replaced, as there is not now a single sound timber in it.

Whatever works the Directors may resolve upon executing at the present time, I should recommend that all those parts of the new piles which will be always beneath the water, as in the pier head and the adjoining bays, be scupper-nailed after the application of a coat of purified mineral tar, which should be put on hot, and in small quantities, frequently, so as to admit of its impregnating the wood as fully as possible.

The lower flights of the first and second stairs on both the eastern and western sides of the pier, have been entirely destroyed and carried away. For the second or middle stairs, I would recommend the entire removal of the flights on the shore side, and with the parts of these which remain the others may be repaired. For the first stairs new piles will be required, new stringings to the lower flight, and new treads and rails from top to bottom. The landings also must be repaired. In the middle stairs on both the eastern and western sides, there are thirteen piles, all of which are much eaten by the worm. New short piles will be required, and new strings, treads, and hand-rail.

The Railing. All the railing requires painting.

Toll-Houses. The toll-houses need various repairs, and some alterations are required for the convenience of the company's servants, but as it will, I believe, be found desirable to remove them at some future time, I cannot recommend any extensive repairs until the Directors have decided whether this suggestion shall be adopted.

Sea-Wall. The sea-wall has been much injured by the undermining of the foundations by the sea, and by the removal of beach, which has been permitted to a great extent. The latter evil has been stopped by a recent order of the Directors, and it only remains to correct the other, which may be partially effected by the construction of a groyn, or more effectually by rebuilding and throwing the wall back.

The result of my survey I may now comprise in the following particulars of the works which should be immediately undertaken, with an intention of carrying forwards the necessary repairs, by the annual execution of a part of that which will remain, until the whole is completed.

1. Protect all the sound timbers by a coat of purified mineral tar.
2. Introduce a few new piles, scupper-nailed, between the toll-houses and the middle stairs, where they will strengthen the bays, and continue the casing if satisfied with that mode of preserving the piles.
3. Ten or twelve new bays between the first and second stairs would be desirable, but less than eight would not be effective.
4. Introduce twelve or thirteen new bays between the middle stairs and pier-head.
5. One entire new bay in pier-head, and about six new piles, all scupper-nailed, and well payed with tar.
6. Repair and reinstate all the stairs, driving such new piles as may be found necessary for their support.
7. Take down the dilapidated portion of the sea wall, and rebuild it, with sufficient foundations, on a line with the other parts of the wall; or repair the wall as it now stands, and construct a groyn for the accumulation of beach to protect it from the tides.

After fully considering this Report, the Directors resolved to commence the repair of the pier, and arrangements being made for that purpose, drawings and specifications were prepared; and, in the following December, tenders were received and contracts made. But upon a further examination of the pier, it became evident that, however desirable it might be to restore all the piles of each of the bays in succession, so as to prevent the necessity of a second disturbance of the superstructure, it was impossible to adopt that plan with safety. There was no hope that the piles could last through more than one or two winters, and, under such circumstances, it seemed injudicious to complete every sixth or seventh bay, and leave the intermediate ones to the chance of the storms, without any increase of strength. It was, therefore, resolved, that the external piles should be first restored, and for this purpose it was absolutely necessary that old piles should be drawn and new piles driven in the same holes, for it was by this mode alone that the entire structure could be strengthened. That this resolution was founded on a sound judgment of the state of the pier, and the probabilities of extensive injury during that or the following winter, has been repeatedly proved. On several occasions since the new external piles have been driven all the internal piles of two or three consecutive bays have been broken during heavy weather, and in the storm of the 4th of February last, all the old internal piles of six consecutive bays were broken, so that the pier, for that extent, was supported entirely upon the external piles. If any other plan had been adopted in the restoration, the pier would probably, at that time, have been destroyed.

By the resolution of the Directors to draw all the external piles that were so much eaten by the worm that they could not be preserved for further use, and to drive new piles in the same holes, the difficulties of the work were greatly increased. In drawing many of the piles, many of which were driven seventeen feet into the tenacious London clay, a force equal to one hundred and twenty tons has been employed, calculated from the sectional area of the links of fine iron chain broken in the work, and yet the pier was in so weak a state, that no portion of that pressure could be allowed to come upon it without the certainty of crushing. In addition to this difficulty, there was that of having to attach the chains to the piles, for drawing, many feet below the level of the lowest spring tides, and generally in a heavy rolling sea. If it had been possible to have closed the pier, for a few months, or to have chosen the calmest season of the year for the work, my difficulties would have been more easily overcome, but from the commencement of the restoration to the present time, the pier has not been closed for a day, and all the hazardous part of the work was executed during the most stormy period of the year.

With the plans I adopted in the execution of the works, you are, from your constant inspection during their execution, well acquainted, and it is, therefore, unnecessary that I should do more than briefly mention them, and this I do more for the purpose of record than to communicate information with which you are unacquainted. It was, as I have already stated, impossible to draw the piles from the pier itself, standing as it did upon timbers which, although originally fourteen inches in diameter, rarely exceeded five at the parts exposed to the worm, and the majority not more than two or three. I therefore constructed a frame work of timber, consisting of an upright, with braces on either side, supporting an extended base, framed to the rake of the piles. This derrick was fixed to the side of the pile to be drawn, and upon it was placed the screw from which the power was obtained. In this manner, the pier itself was relieved from all pressure except that of a double purchase crab, which was sometimes used to assist the drawing when the pile was started; but even this assistance could not, in all cases, be obtained, from the extreme weakness of the piles which supported the platform.

The piles were most eaten away between low-water mark and the ground, but the wire-worm has gone into the sand to the depth of a foot or eighteen inches. It was therefore necessary to sling the piles upon the sound wood in the clay. For this purpose a strong wooden casing was employed where there was only three or four feet of water, and in deeper water an iron caisson. Near the pier head, where there is seven or eight feet of water at the low-water mark of ordinary spring tides, the caisson could not during the winter be used, and divers were employed to sling the piles. You are well acquainted with the difficulty and delay attending this portion of the work. It was only during spring tides that we could attempt to sling the piles at the seaward end of the pier, and the water was then frequently held up and agitated by strong winds from the north and north-east. Even when the chains, which were an inch and a quarter or an inch and three-eighths in diameter, were firmly attached, they were often unable to bear the strain, and broke; so that many of the piles were slung four or five times before they were drawn.

Such were the impediments attending the restoration of the pier, but they have all been overcome; the structure has been saved, and the most arduous part of the task has been completed. All the external piles so much eaten as to require restoration, have been replaced with new timbers, scupper-nailed, and many of the central piles of the five-pile bays have been restored with square iron piles. More than two hundred and fifty new piles have now been driven, and these have given to the pier such increased strength as will greatly facilitate the execution of such works as yet remain to be done. A comparison, therefore, between the state of the pier two years since, and at the present time, must be as satisfactory to the proprietors at large, as to you who have thus far succeeded in your plans for its restoration.

During the progress of the works I have been careful to study the habits of the animals which have so rapidly destroyed the timbers of the Herne Bay Pier. There are two kinds of sea-worm which attack timber on this coast; one is called the auger-worm, and is the *Teredo navalis* of naturalists, and the other is the wire-worm. The Teredo enters the body of the timber, where it is constantly working away the fibres longitudinally. Hundreds of these are frequently found in a single stick of timber, varying in length from two to about fifteen or sixteen inches. As they bore into the wood they form their shells, and it is remarkable that these shells are not ever pierced by other animals of the same species, but the most tortuous forms are produced by the necessity of one animal avoiding the shells of others. Continually working upon the timber, a colony of these animals reduce it in a few years to the appearance and strength of a honeycomb. The Teredo is abundant upon the eastern coast of England, but I doubt whether it is quite so destructive as upon the Sussex and Hampshire shore, although it has done much mischief to the piles of the Herne Bay Pier. Some piles, however, which have been drawn, eaten through by the wire-worm, have been scarcely touched by the Teredo. I believe the Teredo is most abundant upon gravelly bottoms. Near the middle stairs there is, under the pier, an accumulation of beach, although shifting banks of sand lie on each side, and it is in this part that the Teredo is found to have produced the greatest amount of mischief. The part where the piles are least attacked by the auger-worm is near the Incline, between the Incline and the second stairs. The blue clay is there remarkably hard, and is covered with sand or beach two or three inches in thickness. The clay is so hard between the Incline and the second stairs, that working with a monkey weighing 15 cwt., and with a fall of 30 feet, the piles were frequently driven at the rate of not more than half an inch to six blows after driving about ten feet. From the pier head to the end of the Incline the clay is hard, though less so than the part just mentioned, and is covered by a soft mud and fine sand, from a foot to eighteen inches in thickness, and there also the auger-worm has done much mischief to the piles. It is extremely difficult to ascertain the cause why the Teredo should attack the piles in one part more than another; for, judging from the state of the timbers in the Herne Bay Pier, it cannot be accounted for solely by an alteration in the character of the bottom, and yet, as I have already stated, there is some reason to believe, that they are most abundant upon a beachy ground.

But although the Toredo has been very active, it has not produced the same rapid destruction as the wire-worm. This animal attacks the pile upon its external surface, and is constantly at work, reducing the diameter of the timber, in which it is greatly assisted by the friction of the water, which wears down the parts weakened, and as it were disintegrated by the worm. Like the auger-worm it avoids the knots, and the parts that contain turpentine. In every portion of the pier it has been equally destructive, all the piles being more or less attacked, but those are, as may be expected, in the worst state which are always under water, its action being there unceasing.

The first, and indeed the best account of the wire-worm that I have met with is that given by Smeaton in May 1778, in his report on the Bridlington Piers. The description of this accurate observer, who in soundness of judgment and readiness of invention has never had a superior, if an equal, among engineers, is worthy of every attention.

"This worm appears as a small white soft substance, much like a maggot, so small as not to be seen distinctly without a magnifying glass, and even then a distinction of parts is not easily made out; it does not attempt to make its way through the wood longitudinally or along with the grain, as is the case with the common ship's worm, but directly, or rather a little obliquely inward; the holes made by each worm are small proportioned to the size of the worm, but as they are so many in number as to be but barely clear of each other,—as they do not appear to make their way by means of any hard tools or instruments, but rather by some species of a dissolvent liquor, furnished by the juices of the animal itself,—it follows that, as the animals which overspread the whole surface of the timber exposed to their action, proceed progressively forwards into the body of the wood, the outward crust becomes macerated and rotten, and gradually washes away by the beating of the sea, so that, in fact, the timbers, planks, &c. gradually waste in size and thickness, till, at last, becoming too weak to support the strain upon them, they are obliged to be replaced and new done many years sooner than would happen by the natural decay of timber in such circumstances, if unaffected by the worm.

"The worm is found lodged in a crust of wood, generally from a quarter to half an inch deep, that part of the wood under this crust remaining perfectly sound. The rate of progression, as I am told, is, that a three-inch oak plank will be destroyed in eight years by action from the outside only.

"It is furthermore observed, that those animals do not live except where they have the action of the water almost every tide, for they are not found in the timbers above the level of common neap tides high water, or, indeed, scarcely so high; so that it is to be inferred, that if any happen to fix so high as the common neap tide mark, if a few low tides fall out together with still water, as frequently happens in summer, the worm thus unwashed dies, and a stop is put to its further progress higher.

"Again, it is very obvious that so high up as the piles and work are covered with sand, or as soil lies against it, the wood is perfectly freed from the worm, so that the parts affected are what are also exposed to the air, that is from the surface of the ground or sand to high-water neap tides. Whether a deprivation of the action of the sea-water, accompanied by a continual change every tide, or a deprivation of the action of the benefit of the free circulating air each tide, occasions the loss of what is necessary to their subsistence, may be a question, but which indeed, it does not seem necessary now to resolve; this, however, is the fact; for on the inside of the planking against which the ballast, sand, or gravelly matter which is heaped by way of filling and giving solidity to the pier's base, and which in general is filled above high-water neap tides, is also found to be a preservation to the inside of the planking, though from the outside only they will waste, as has been said, three inches in eight years."

Smeaton has greatly under-rated the destructive action of this worm. He speaks of a three-inch oak plank being destroyed in eight years by action from the outside only. But in Herne Bay Pier there is an oak mast eighteen inches in diameter which was eaten through in six years, and the destruction of the piles generally has been scarcely less, although oak is more rapidly destroyed than fir. But there is also an error in his description which I have found very prevalent among engineers, and should be immediately corrected. He says that the parts covered with sand are untouched, and that timber to be affected must be exposed to the air as well as the water. I have already stated that the worm enters the sand to the depth of twelve or eighteen inches, and for this reason I have continued the nailing of the timber piles to that depth below the usual level. That the worm can act in deep water upon parts which are never exposed to the atmosphere, we have abundant evidence, for it is this circumstance which has caused at once the destruction, and the difficulty of restoring the pier.

To prevent the worm from attacking the new exterior timber piles, which were preferred to cast-iron for that situation, the parts beneath the low water neap tide were scupper-nailed. This was necessarily an expensive process, but being the one best tested by experiments, it was adopted in preference to other plans, which, though cheaper, were not equally certain of success. Such of the internal piles, however, as were restored, were replaced with iron piles, of the form represented in the drawing. The object I had in view in designing this pile, was to secure the driving beneath the platform, in which I fully succeeded. The iron pile being driven, the upper portion of the timber pile, which is perfectly sound, was introduced, and bolted in such a manner as to be brought close to the two sides continued above the square portion of the pile. An angle piece was then fixed with coach screws, so as to complete the casing round the timber, to a height above high water, and the intermediate space between the timber and iron was filled with a hard bituminous cement not acted upon by sea water. In this way I have prevented any racking of the timber upon the bolts, which would have been the result if the bolts had been carried through the square iron pile. For the internal piles which may be driven at a future time, no better form can I think be adopted.

Having very briefly described the present state of the pier compared with its condition when the restorations were commenced, and the manner in which the necessary works have been performed, I will only further remark, that the permanence of what has been accomplished must in a great degree depend on its being kept free from all those accumulations which are so rapidly produced upon works exposed to the action of the sea.

SOUTH EASTERN HARBOURS.

[The following is the speech of W. A. Mackinnon, Esq., (M.P. for Lymington,) on moving for a select committee to investigate the revenue, expenditure, and condition of the harbours on the coast, from the mouth of the Thames to Portsmouth, in the House of Commons, April 27th, 1843, extracted from Hansard's Parliamentary Reports.]

Sir,

In rising to move for a committee for the purpose of investigating the revenue, expenditure, and present condition of the harbours from the Thames to Portsmouth, I will, as concisely as the subject will admit, state the object of my motion. It is a subject of very great importance to the trade of the empire, and to the security of navigation. I am aware that a committee on shipwrecks is now sitting, but that will confine its inquiries to the question how far it is expedient to educate mates and masters of ships for the merchant service, or to find some place of refuge in bad weather; the committee that I require is to supply funds for a harbour of refuge, or to give back to the Treasury large sums now raised by tolls to no purpose, or, if these sums, it appears, are not required, to ease the shiping interest of a heavy and useless payment of dues, which dues at present are wasted in a manner unprofitable to the country or to navigation. The House is aware, that in 1840 a commission was named by the Queen, to ascertain the best site for a harbour of refuge on the coast. The Report of that commission stated, that amongst other places, one between Margate and the North Foreland, the other in Dover Bay, and a third near Beachey Head, were eligible for the purpose; and that the cost of a harbour of refuge might be about two millions. Mr. Cubitt, the engineer, however, thought a harbour might be formed at at a much less cost, to answer the purpose equally well. The House must understand, that by a perfect harbour of refuge, is meant a harbour accessible at all times of the tide by vessels of any tonnage, the mouth of which is so placed as to be entered easily with the most prevalent wind. Every person of the slightest knowledge in maritime affairs must be aware of the vast importance in our trade of such a harbour, both in times of war and of peace, particularly as every year steam navigation and the intercourse between nations considerably increase. I am one of those who do not anticipate the probability of war, but think there is no doubt that the communication between England and other nations will considerably increase. Now, such a harbour of refuge in one of the spots just enumerated, is most desirable. I am fully aware, that the treasury of the country ought not, if possible, to be called on to supply the means, and I think I can point out to the House some method of obtaining a fund for that purpose, without increasing the burdens of the country. If the funds received from tolls on passing ships are now wasted or misapplied, why should these funds not be made applicable to the formation of a harbour of refuge? If the House do not sanction such an application, then ease the shipping interest of the burden, and levy no more on the commerce of the country than the amount absolutely required to keep the present harbours in repair. That such tolls so levied are misapplied, I will now prove to the satisfaction of the House. I will begin with Ramsgate Harbour, and "*ex uno disce omnes*" The House must learn, that by an old Act of Parliament, the trustees of Ramsgate Harbour levy 4*d*. a ton on all foreign ships, and 2*d*. a ton on all British ships that pass the Foreland which are above 300 tons burden: those under that tonnage pay rather less. This tax is levied to keep up Ramsgate Harbour, and to be continued as long as this harbour wants repair! By this paper in my hand, printed by order of the House on my motion last month, it appears this rate in 1841 gave to Ramsgate Harbour 19,065*l*.; and with some other dues the trustees obtain an average income of 20,651*l*., besides a balance in hand of 5,694*l*. Now, I will show by evidence that 7,000*l*. a-year is more than sufficient for the repairs of Ramsgate Harbour, which harbour, it is notorious, cannot receive vessels above 450 tons burthen —so you tax British and foreign vessels 4*d*. a ton for a harbour which can by no possibility be of any use to them. Was there any thing so monstrous, so absurd, or so unjust? You commit an act of injustice by such a toll; and you injure all the other harbours on the coast, because it is notorious that foreign vessels will not, for fear of paying this unjust toll, stop at any English harbour if they can possibly help so doing; but they run over to the French, or Belgian, or Dutch coast, where such exactions are not made; the result is an injury to our sea-ports, by preventing the expenditure of foreign ships in them. Now, to show the House the waste of money that takes place at Ramsgate, I will refer to the evidence of Sir William Curtis, the head of the trustees of that place in 1822:—

"Foreign Trade Committee,
April 26, 1822.

"Sir W. Curtis examined.

"*Q*. What ought to be the annual charge of keeping the Harbour of Ramsgate in repair?—*A*. It will require some little calculations from the books to answer that.

"*Q*. Do you think that from 5 to £7,000 a-year would be sufficient?—*A*. Yes, it might do.

"W. Domet, Esq., examined (p. 276).

"*Q*. Do you consider the benefit to the shipping to be in proportion to the money laid out at Ramsgate?—*A*. Far from it; many thousand pounds have been laid out, of no use whatever. Men are constantly hammering stones.

"*Q*. Do you consider the benefit to the harbour adequate to the expenditure of £20,000 a-year?—*A*. No, certainly not; far from that. (p. 271.)

"George Good, Esq., examined.

"*Q*. What has in the last six years been laid out on Ramsgate Harbour?—*A*. £147,538, with little or no advantage.

"*Q*. Do you think the advantages derived from Ramsgate a sufficient compensation for the expense drawn on the shipping?—*A*. No, certainly not.

"*Q*. Do you know the manner in which the duties are levied on foreign shipping?—*A*. I do not; but I know it is that of which they very much complain."

Not to fatigue the House by reading all the evidence, I will only add, it appears that in 1822 the Committee said that 8,000*l*. a-year was quite sufficient for Ramsgate Harbour; since which period the trustees have received upwards of 400,000*l*. Some years ago, a banquetting-house for the trustees to dine in, only once in each year, was erected, and it has cost 3,500*l*.: it is of no use whatever, and that from its first formation to the present time, that harbour has cost the commerce of the country an enormous expenditure, not less than 1,500,000*l*. To sum up the evidence of Sir W. Curtis, an unwilling witness, Captain Domett, and Mr. Good, it appears this harbour is of no use but to small vessels about 350 tons and under; can only be entered at particular times of the tide, and that in a gale of wind, when shelter is required, the danger of entering the harbour is very great; and that the sum of 7,000*l*. a-year is quite sufficient for every possible purpose required. Now what is the case—the sum of 20,000*l*. a-year is collected by dues on large vessels, British and foreign, to which the harbour can be of no possible use, and this money is wasted in the most wanton manner. Let one of these two measures be adopted—either relieve the shipping interest from these most vexatious, useless, and unjust tolls, or, if they are continued, apply them to some useful purpose. Why not in the latter case commence a harbour of refuge in some eligible spot on the coast? The surplus fund from Ramsgate Harbour alone would be, say 12,000*l*. a-year; from Dover Harbour, probably 8,000*l*. a-year, besides many others; here you have at once a fund of, say 20,000*l*. year, which will establish a sinking fund, or, pay the interest of 400,000*l*. for a harbour of refuge, and not put the country to one shilling more of expense. At the same time, I am fully aware of the talent and ingenuity, and of the powerful interest both in this House and out of it, of the trustees of harbours, and of other parties connected with these tolls; but let us have fair play—let the House give me a Committee; I defy them to disprove one single assertion that I have made. The right hon. gentleman, the Member for Kent, shakes his head,; well, I call him to the proof —let us have a Committee; if he can disprove any material assertion I have made, I will admit he is right. But why shrink from the severe test of an examination and a Committee if all is right. I repeat, these abuses ought to be corrected—gross jobs cannot be tolerated in the nineteenth century—either prove as you ought to do before a Committee, that the harbours on the coast from the Thames to Portsmouth require all the money they raise on tolls, or let that money be applied for the security of navigation, and the safety of seamen; or give up these at present vexatious and unjust tolls, and relieve the shipping interest from these burthens. Either investigate and prove the case, or let the trustees voluntarily relinquish those immense sums now ex-

tracted from vessels passing the Foreland. Let the House consider also, that these revenues will increase as commerce increases; and that the time is come when an investigation ought to be made of the manner in which these large sums are expended. I am aware of what I have to expect from the parties opposed to any inquiry—I well know their talent and ingenuity—but I trust the paramount duty of the members of the House will supersede all other considerations, and that no further opposition will be made to a Committee. Sir, I beg leave to move, &c.

THE REPORT OF W. B. PRITCHARD, ESQ., C. E.,

TO THE COMMISSIONERS OF SHOREHAM HARBOUR, ON THE CAUSE OF THE EXISTENCE OF THE SHINGLE BAR AT THE MOUTH OF SHOREHAM HARBOUR, AND THE PROPOSED MODE OF KEEPING THE MOUTH OF THE SAID HARBOUR PERMANENTLY FREE.

[THIS Report has the great, and we must confess, very uncommon merit for a harbour report, of doing what the author professes in his title page. There are but few reports upon bar-harbours by modern engineers which enter fully into the causes of the evils their authors are required to correct; it is for this reason that they are so unsatisfactory to the man of science. No one at all acquainted with the engineering history of our harbours, or with the reports that have been written upon them, can for a moment doubt that the opinions generally entertained by engineers, and upon which they have reasoned and acted, are erroneous, for in but few instances have the results of their works been such as were anticipated. All practical men are so fully convinced of this, that the engineers whose names stand prominent among the professional men of the age skilfully contrive to avoid the subject, and endeavour to satisfy their employers by the recommendation of some works which may succeed in removing an impediment, but can never prevent its formation. It is therefore no small merit to the author of this Report that he has boldly investigated his subject, and frankly stated his conclusions. We shall take an early opportunity of examining the opinions of modern engineers upon the formation of bars, and shall therefore defer our remarks upon Mr. Prichard's Report. The following extracts will probably lead the reader to an attentive perusal of the Report itself, which, during the last month, has been published by Mr. Weale, and is worthy of more than a casual examination.—ED.]

THE subject of this Report is divided into two heads, viz.:

1st. *The cause of the existence of a shingle bar at the mouth of Shoreham Harbour.*

2dly. *The proposed mode of keeping the mouth of the said harbour permanently free from a bar.*

The cause of the formation of "bar" has agitated the mind of the scientific world for ages past, and many indeed are the theories advanced and promulgated to account for their formation; and the subject is one of the very highest importance, so much so, that many works of great magnitude have been undertaken for the purpose of obviating or removing the impediments to navigation arising from their presence.

The bar of this harbour is formed from south-west to north-east and north, across the mouth or entrance to the harbour, and is composed of beach pebbles or shingles, which proceed from the westward, and pass along to the eastward; and its progress cannot be arrested by human art, nor indeed would it be judicious to do so, except to a certain extent.

The *original source* of this shingle, or the fountain-head, is not exactly known, and very probably it is beyond the *Land's End*, but its tributary or auxiliary sources or branches of supply to the main arm may be thus accounted for.

It consists chiefly of flints, pebbles, &c., and seems to proceed from chalk cliffs that stud a considerable part of the southern coast of England; these cliffs being gradually undermined by the element in its incessant warfare, reduce the opposition occasioned by projecting masses, the super-strata are hurled from their heights, and these procumbent masses of chalk and flints being battered *en detail* by the merciless billow, and reduced in its bosom into fragments, are swept by the maddening tempest along shore from the locality in which nature had originally deposited them.

The cliff being dissolved by the counteraction of the sea, frost, and air, dislodges from its matrix an immense quantity of flints, (hence the blue boulders,) and these being broken, and incessantly rubbed against each other, are rounded by the friction, and pulverized; although I believe that shingle and pebbles are substances originally prepared by nature, and as ancient as the creation; yet the shingle beaches, by being impelled by the impetuosity of the foaming seas near shore, rolling over and striking each other, must break and continually wear away, as a manifest sign of the abrasion: although the "incessant murmur" that is heard in storms on this coast is less the effect of the mutual shock of the wave, which marks the action of the "waters on the air," rather than the pebbles moved and tossed about; for even in their process of rubbing and crushing each other they could not emit a sound to reach our ears on shore, as these are covered with the sea in depth many feet; however, the shingle, by their mutual collision and friction, become round, constantly diminish in bulk, and by degrees smaller pebbles, and at last ground down to what is commonly called compo, by this process, forms a constant succession of beach or shingle: their first surface appearance being in vast quantities in Chesil Bank, westward of the Bill of Portland, where they form a vast mound, with a lagoon on the land side, and in violent south-west winds, vessels are sometimes driven across the bank into the lagoon.

From the Bill of Portland eastward little or no shingle appears in shore, but there is a large accumulation about the Needles, which is continually shifting, but does not enter the Solent, except a little way about Hurst Castle, at the back of the Isle of Wight; it is kept out at sea up to Selsea Bill, and thus, with the exception of a little shingle about Portsmouth, the banks in the channel between the Isle of Wight and the main land are a soft, sluggy deposit. From Selsea Bill to Shoreham, and eastward to the Downs and Sandwich Flats, they are to be met with like an Egyptian plague.

The motions of this great body of shingle are commonly attributed to the currents on the coast; that *such notions are erroneous* I shall satisfactorily prove. The velocities of the currents on this coast are not sufficient, nor can they possibly act on the shingle or pebbles of every dimension that are carried forward, but are impelled forward by the *waves, breakers, or seas,* acted upon by the prevailing winds on each coast or channel. Thus:—

The British Channel opens to the westward, without any intervening land to break their force between the Atlantic and continental Europe. It contracts to the eastward,—the general set of the winds, and the tidal waves, blows from the south and south-west, and often with great violence. The seas and waves, therefore, are much more violent and heavy from the south-west than from the south-eastern quarter; hence the constant motion of the shingle driven by the action of the sea coastwise and their destination eastward; and when I say thus, that the shingle always travels in the western channel to the eastward, the very reverse is taking place with the shingle in the North Sea, which is always travelling to the westward. It is done by the sea and waves, the one being open to the south-west swell, at least the prevailing winds being from that quarter, the sea striking from the south-west rolls the shingle to the eastward. Whereas, in the North Sea, the prevailing winds being northward and eastward, roll the shingle along in the opposite direction; there the beach or shingle meets eastward of Deal, in Kent.

The tides of the ocean are here divided into two branches, the one going up channel, the other going north; but coming down the eastern side of England, meeting east of the Downs, causes a conflicting action between the tidal waves and swell. The beach thus in suspension is hurled into the bosom of the mighty waters, carried by the conflict, and lost in deep water, obtains a state of rest; as it has been ascertained by practical hydrographers that the sea does not break below six and seven fathoms.

It is essentially necessary that we should have, and indeed no

engineer ought to attempt to construct harbours invested with shingle beaches, without he has practical knowledge of the movements of those shingles, and he should acknowledge no authority for his guide except observation.

I shall here proceed minutely and systematically to examine the motions of the shingle at this harbour, with the object of ascertaining the true mode of the formation of the bar, by its movements.

The many experiments I have made, and the observations that have been made during the last year, both in calm and storm, have confirmed my mind as to the soundness of the principle here laid down.

The common phraseology is, that the shingle travels from the west to the east, but strictly speaking, such is not the fact; certainly its fountain-head is the west, and its final destination the east. In my observations on this interesting problem, I shall proceed to illustrate the solution thus: its travels are south-west to north-east, and north to south.

Although its travelling course is less obvious to common observers, yet the course is as above stated.

Suppose we take the beach at a state of rest at Nos. 1 and 2 on the accompanying plan of the entrance, considering the south-west as the prevailing quarter of the storms which most affect the shingle travelling; the shingle thus found, the storm commences with its tumultuous foam, the furious billows are disturbed, and the great solitary wave, or primary wave of translation, hurls it from its resting place up the plane in an oblique direction, till it reaches its new location at letter *a* on the plan. The great wave recedes, and the smaller particles are drawn back with it to No. 2, thus a portion has gained an angle.

The process continues, and the solitary wave hurls them along the plane a second time, from letter *a* to *b*. The abduction of this wave causes another wave, the oscillatory or drawback wave, which draws a portion down with it from letter *b* to *c*, the solitary wave at the same time translating the shingle from No. 2 to letter *c*, and the drawback wave raking a portion to No. 3; the same operation is carried on with all the angles.

The inference therefore is, that the wave of hemicycloid carries them from south-west to north-east, and the oscillatory or *discount* wave draws them from north to south; the process is carried on until the pier is arrived at, on letter *d*. Now this wave of translation continues its course along the line *e*, strikes the east pier at letter *g*, and rebounds from pier to pier, owing to the wrong set of its initial direction in entering the mouth of the harbour; the discount or drawback wave in consequence being unable to maintain its position, and the shingle being of greater specific gravity than the aqueous element, drops its burthen, and seeks a momentary resting place at the letter F. Thus the shingle is brought to the harbour, and no piers could be better formed in their original position for being a *suction to draw shingle to the harbour's mouth.* * * * * *

I shall now return to No. 1 and letter *a* on the plan, and show another mode by which this body of shingle travels, as stated, from south-west to north-east, and north to south, and ultimately its destination eastward only, viz.:

After a long continuance of storm, the translative action being greater than the discount action, an increase of beach takes place westward of the west pier, at letters *h*, *g*, *b*, *k* and a great part thrown up from the reach of the next tide. In a few years a greensward covers the beach, unless interrupted by some extraordinary circumstances, tending to infringe westward on the watery world, the work of decreasing the excrescences and filling up the indentations to the pier, is continually carried on by the aqueous element.

The wind shifts to the northward, or from land, and most likely calm for several days; the tide flows up the plane of the beach, and falls at an angle of repose, gives more or less impetus to the dispersed waters; the plane being greater than an angle of forty-five, the water runs down with rapidity, from its specific gravity, and draws down with it a body of atmospheric air underneath the succeeding wave; this second wave rebounds over the other, increases in strength, and the wind from the land assisting the drawback, the beach is raked down in immense quantities, north to south along the line from *h* to 1. This being repeated on the several divisions, the beach is formed at 1, 2, 3, 4.

Again the storm commences, the translating action comes into full force, and the shingle brought down during calm is hurled as before along the oblique planes, gaining therefore an angle at each and every operation, until their ultimate destination is eastward, meeting the North Sea.

On close examination of this true mode in which the shingle travels, you will find that the west pier at present, being almost a direct barrier across the track, answers as a nucleus or nursery for the beach, and by the translating motion of the sea an immense quantity finds shelter on the west side of the west pier, by being interrupted in its course; but in a calm the waves at the pier, by being debarred of their full force, return with renewed vigour, and bring a quantity of beach down to letter *d*, (so much so that in two days of calm after storm, within fifty yards of the pier, 400 cubic yards by measurement were drawn down,) the moment the translating action commences, this large quantity is hurled from *d* direct into the harbour's mouth at F.

I have thus far followed this mass of shingle to the throat of the harbour, and I shall now describe by what means the large quantity accumulates along the west pier from F to M: the shingle as before observed (or at least eighty per cent.) enter's the harbour's mouth and is deposited at F.

Suppose we were to commence at low water, (after the shingle has entered and is deposited at F,) the flood appears near the south end of the west pier; on its way, it first encounters the shingle bank deposited at F in an inclined plane or an irregular mass, and rises up in succession of planes and small elevations: the first ground wave thus formed at the lowest part of the plane continues its course, another wave follows, and on arriving at the acclivity rises over it by the effects of pressure of the undulation of the mass on its outer flank, and becomes merged in the first ground wave formed on the plane; the ground waves thus produced by the effects of the several successive elevations or abrupt beds of shingle, are of a greater volume than those of a single elevation, although the latter are equal to all the smaller ones, by reason that at every obstruction the ground waves, (or "*Flots de fond*,") by being raised upon the surface wave, lift with great fury the surf; the irregularity of the bed, the acclivity, and the abrupt slope existing thus at the mouth, the ground waves rise in encountering the obstacle, and being no longer able to continue their course under the influence of the tidal stream, because their movements cease to be in harmony with the undulation, advance upwards and flow backwards at the bottom, unable longer to uphold their position, *rush forward with mighty grandeur and almost immeasurable rapidity, and produce along the pier the phenomenon called the "bore."* Or in other words, the tidal bore alongside of this pier is formed at the commencement of the flood tide, moving with a velocity so much less or inferior to that of the succeeding tidal wave, or the one that strikes against the south end of the west pier, and is so much thrown in an oblique direction, abruptly contracted and compressed, is hurled forward with so much violence, arrives in a point at the same moment with other waves, the re union of those waves forms a "bore;" the several waves thus formed into one, their lateral section being contracted, their depth by this body of shingle compressed, the union of their strength forms one mighty wave, or bore, and advances along the pier with prodigious rapidity, four times the velocity of the later current, (as all elastic or non-elastic fluids have a tendency to adhesiveness,) it causes a friction or a stagnation between the two currents. In this eddy you may see boats making their way apparently against a furious tide.

This bore hurls every obstacle, and sweeps the shingle in its way from F to M with reckless contempt, until the north end of the new north groyne is arrived at; there it is allowed expansion, the shingle in its loaded arms is permitted to drop, the succeeding bore striking the skirts of the former drops its load further south, and forms a large bank or inner "bar" alongside of this groyne.

This the harbour-master complained of in his report to you, dated January 17th, 1843, and this bank will always be an annoyance opposite this groyne, until the shingle is prevented entering the harbour's mouth. *Indeed it is only the true effect of a cause; remove the cause, and the effect will cease to exist.*

Two very bad effects are caused by this tidal bore.

1st. The bringing of large quantities of shingle from the harbour's mouth, along the pier, to the north groyne; *this evil will be removed in my operations in preventing the formation of a bar.*

2nd. The bore is the cause of the great swell in the western channel, (in conjunction with another cause I shall hereafter allude to,) so much complained of by masters of vessels, &c., &c., at Mr. Gorringe's quay, the railway and packet quays.

This bore moves along the pier with surprising rapidity; (by some

experiments that I have made I found that in spring tides and stormy weather, the bore travelled along the pier at the rate of 250 feet per second;) continues its course to the north end of the north groyne; being here allowed to expand its furious billows, it is reduced apparently to fragments; a convulsion and agitation is caused thereby in the whole surface waves, the vibration rebounds from pillar to post, and its effect is felt at the above named quays.

To obviate this, I propose to construct a breakwater of open piles, at a cost of a few pounds, as shown on the plan at R. Thus will the bore be interrupted in its course, its strength diminished, its body reduced into harmless sprays, and the surface swell in a great measure will cease. * * * * * *

There is nothing, I believe, so essentially necessary for the good preservation of the harbour as the free ingress and egress of the tidal waters. The flood tide has unnatural obstacles which ought not to exist, or the irregularities of the surface at low water to overcome, the fall of the bed being so great at the embouchure of the river, the first flood on its entrance is dammed back and unable to maintain an upward course and overcome the impediments; the effluent backwater being so powerful, a conflict takes place between the two currents. This is maintained until a great vertical rise of the tide takes place; in this conflict the tidal current, owing to its greater specific gravity, occupies the lower stratum, and being unable to wedge its way, raises the effluent water, and a swell arises in the surface waves which is apparent to all.

In consequence of this conflicting action, the shingle is deposited along the western pier, being the course where least resistance is offered to its presence, the construction of the channel, owing to the unnatural elevation of its bed, must immediately have the effect of bringing into collision those opposite moving masses of water, and the great swell becomes apparent and continues its course higher up the river.

The great rise of the bed of the river from its entrance to the railway quay, is a great auxiliary to the formation of the bar, and retards the ground waves in their upwards course.

I wish here to impress upon your minds, that there is not an instance in Great Britain of a harbour having so much fall at its entrance as this harbour, and most likely not in the whole globe; our noblest harbours and rivers, the Thames, Mersey, Clyde, Dee, Avon, and Tyne, &c., have not as many feet in miles.

The consequence is inevitable, that as soon as the flood tide has gained sufficient head above old Shoreham Bridge, and the limits of your harbour, and expands on the marshes, the tidal current runs with great rapidity past those wharfs, quays, &c., just as a vessel is lifted from the ground; such in fact as any harbour, where vessels lie at their berths, ought not to be subject to, especially when those quays are acted upon by the ingress and egress of tides.

The same effect is consequently produced on the return of the tides and the effluent waters, especially if assisted by the upland freshes.

Should the bed of the channel be excavated, the tides in entering would have a *free and easy ingress and egress*, and be able at once to retard or return the effluent water. The river being in this perfect state, as regards the slope of its bed, at low water, a consequent attendant upon the latter will be *an equal duration, or nearly so*, of the period taken up by the flow of the flood tide and that of the ebb, from the upper quays to the mouth of the harbour, and being thus in harmony with each other, the ground waves, and consequently the surface waves, will be more tranquil, and smoother water and the unnecessary rapidity of the channel modified. * *

I shall now return from high water down with the tide and effluent waters in ebbing out to sea.

I have ascertained by experiments with the travelling and registrating buoys and the tachometer, that the scouring power does not commence in this harbour on the ebbing of the tide until three feet of its surface be reduced, or having ebbed out at the entrance three feet; the greatest pressure and scouring power is maintained at five, six, and seven feet from low water bed.

I have stated, that of the shingle entering the mouth of the harbour 80 per cent. was deposited along the pier, and thence carried forward; the other 20 per cent. drops in the track along the line *e*, from *d* to *g*.

In the process before explained the track of shingle is formed each flood tide, if the supply is received at *d*, but the moment the tide returns, it is carried clean and clear in its arms and deposited on the bar, the other part of the shingle being deposited on different parts of the west pier and groyne, as before stated, the immense body of hydraulic pressure, and the rapidity of backwater returns, and commences the work of destroying the accumulation of the flood, hurls it along from the north groyne and different divisions of the pier lifts the shingle in its arms, and shoots it, as if from a cannon of great calibre, in a direct angle with the shore to sea. Thus the backwater with its great scouring power, with its arms as if full, *runs directly into the face of a greater and stronger body than itself, a war is waged between the two*, the backwater, which a few minutes before was irresistible in its course, finds its opponent of much larger body, assisted by the gales and winds, infinitely stronger in the conflict, the backwater gives way, unable any longer to maintain its ground, *all the shingle and smaller particles in suspension drop down; these form the "bar."*

This bar would increase and rise to a great height, if not for the almost irresistible power of the south-westerly winds and gales moving the particles composing it along the line *t* to the eastern groyne.

I cannot too strongly impress on your minds, and I wish to call your most serious attention to the following facts, and sum up in a few words the mode by which the "bar" is formed at the mouth of this harbour, viz.:—

The first mischief, or the vortex of the plague, is in allowing the shingle to enter the harbour's mouth; the great power of the backwater takes it out again; that backwater, tidal and effluent, being conducted by the present piers out to sea in a direct angle with the shore, into a greater body than itself, is the true cause of the formation of the bar. And if you could by mechanical means, by sluices, reservoirs, &c., obtain instead of three million tons of water (as at present) twenty million of tons, and increase the velocity threefold, I am as certain as of my own existence, *that the bar would increase in proportion so long as the backwater, tidal and effluent, with the present slope of bed, is conducted in a direct angle with the shore to sea.* Such would be the case if you had the waters of the mighty Nile, Plata, Amazon, Gironde, and Orinoco; take, for example, that queen of the watery world, the Mississippi, with its backwater, which is obstructed by six bars, having on them less water than the Thames; and mouths of other rivers utterly insignificant in comparison to the Mississippi as regards the immense volume of water it discharges.

2ndly. *The proposed mode of keeping the mouth of this harbour permanently free from a bar.*

The most important improvement connected with this harbour, is the subject of this Report, and which in fact is the *key to the possession of a good harbour.* Keep it free from a bar, and you have a clear entrance to your estate. I shall now show you by what means (*and those means within your reach*) this desirable end may be obtained: viz.:—

1st *By means of the south pier and its peculiar angles, to prevent the shingle entering the harbour's mouth.*

2ndly. *By the extension of the present western pier, with its peculiar angles, in sending the backwater, tidal and effluent, with all matter in suspension, in its natural direction, an acute angle with the line of coast seaward.*

I hereby propose to extend the present west pier 240 feet, as marked on the plan with the letter Z; this extension will guide the backwater in its natural course, being an acute angle with the superior pressure and body of the tidal waves, in lieu of in the face and against the sea; and all matter in suspension, either alluvium, sand, or straggling shingle, will, on being carried forward by the backwater, and entering the tidal waves in an oblique angle, be assisted and carried also by the waves forward, in its natural course to the eastward.

The pier, marked with the letter *n*, (which I shall term the south pier hereafter,) will conduct the shingle in its travelling course, by its oblique angles from the westward, and on arriving in its course at the face of the south or conducting pier, the superior power of the south-west gales, winds, and waves, owing to their natural inclination to escape at a tangent to the opposing line, on encountering the inclined face of this artificial promontory, will give such a curvilinear and additional impetuosity to the waves and currents having the shingle in suspension, as tend to pass the beach into the regurgitating wave in succession, and will follow or carry its load along the line P, to the eastward of the harbour's mouth, this being the natural line of travelling the beach seems to take.

By this means the shingle will not be permitted to enter the harbour's mouth, but be assisted in its progress eastward. Thus, the

shingle being prevented from entering, the backwater has no shingle to return and form a bar; the cause of the formation of the bar being removed, the effect as a matter of necessity must follow. It will then be as much the nature of the shingle to pass and keep its travelling course beyond the harbour's mouth, as it is the natural inclination of the shingle at present to enter the harbour. Consequent on this reversion, the law of nature will extend its protecting arm, (prevention being better than cure,) *no "bar" can possibly form at the harbour's mouth.* * * * * * * *

I will now lay before you my reasons by practical facts deduced from nature, that such ends will be obtained by the proposed extension and the south pier.

Let me not be misunderstood by saying that the mere extension of the west pier will have the desired effect of preventing the formation of a "bar." I have no hesitation in saying, that if you were to extend the western pier rectangular with the line of shore another mile seaward, the moment the shingle gained the south end of such angle, it would fill the harbour's mouth as before; and in fact, before the angle on the west side of the western pier was filled, the east side of the east pier, owing to the want of proper supply of shingle, which is essential to its existence, would have been so much excavated, and the impetuosity of the sea, rushing every spring tide, would have made a breach into the eastern arm, that very soon you would have two entrances instead of one into the harbour.

This must clearly demonstrate, that the object must not be to prevent the beach from travelling from the west to the east, but its natural course assisted by art, immersed in the ground waves past the harbour's mouth. * * * * * * *

Bars will always form, in defiance of any mechanical contrivances, if there be sufficient velocity and quantity of backwater to carry matter in suspension in a direct angle, and in the face of a superior and stronger fluid.

Therefore my object is, not by (*any means*) extending the western pier for the sake of length of a barrier in retarding the beach in its progress along the coast, but extending the west pier in the natural direction, and overlapping the present east pier, and by the south pier pass the shingle to the east groyne.

I will now commence with the mode of passing the beach by means of the south pier.

I have no doubt in my own mind, that when the extension takes place which would be necessary before the south pier was constructed, but that the beach of the western side of the west pier would follow, from low-water mark, as fast as the extension was carried out, or at least would very soon follow to the south end of the new angle made by the extension; so we will consider the beach as if it were at the south end of the new extension, lying at the foot of the south pier. If so, the same operation would be carried on precisely by the south-western gales with the shingle as at present on the planes of the plan, from 1 to *b*, and from 2 to *k*, as before explained in the former part of this Report.

On arriving at this spot on the west side of the west pier, the fluid or particles of water being accelerated before they reach the north end, from the increased slope of the surface by means of the opposing angles of the bottom of this pier to the furious tides and waves,—this will be extended to the whole space of the regurgitated waves at this spot,—thus will the waters swell further back up the plane than they would otherwise have done. The tenacity and adhesion of the particles of fluid by means of this acceleration, will extend itself to a greater distance than even the top of this plane, and consequently must occasion the regurgitated waters to retard the other waves, which are on the section of the line of the face of this pier at *n*; thus all the particles of fluid in descending the inclined plane, are accelerated by the very same laws by which all other ponderous bodies are accelerated. The acceleration that arrives from the pressure and regurgitation, belongs properly and peculiarly to fluids, which, as being composed of detached particles, yield to all forces impressed on them, and this force or resistance being placed obliquely to them they are thereby put in motion, and their natural inclination is to escape along this plane. Thus the waves of the south-westerly gales, which mostly carry the shingle forward, on meeting the centre of the plane of the south pier at *n*, this plane being twenty-five degrees towards the most injurious winds, must increase greatly in strength, owing to the regurgitation of the westerly wave; this wave meeting the eastern one, owing to its obtuse escapement, forms a curve, the immense impetuosity of the ground and leading waves will in their natural course shoot the shingle, and all matter in suspension, beyond the line of translation, acted upon by the south-western line of the action of the waves; as fluids at all times, especially if loaded with matter, will of their natural inclination escape very quickly at a tangent to the curve thus formed by each succeeding wave.

This is proved beyond a doubt in this harbour, on the west side of the middle pier; not that the water there has a greater velocity than from the south end of the middle pier to the sea, but owing to those hydrostatic laws no matter of any description could possibly lie against the side of this pier. Neither could it at the face of this proposed south pier: the water and waves being there so much increased by the repercussions of the part above, and the points of angles occasioned by this pier, no lodgement of beach will be allowed to remain one minute, but will be shot seaward, as the force and impetuosity of the waves will be here the greatest, because the whole succeeding waves, from the south west, will be one continued curve; thus the wave flying off with its load along this plane, and battering against the opposite line, transfers its load to the line P, and is carried along by the great primary wave of translation, so there will be a constant renewal of the operations.

(It would not be my intention to carry this south pier only to the height of high-water mark, and that the south-east side at *n* should be one even face of sheeting piles, and present a face similar to a plate glass, offering the least possible resistance to the impetus of the waves.)

There is no law so certain in hydrostatics as the above explained, and by following the same common principle, the most advantageous position that can be given this pier, for turning the waves with their suspended shingle to the opposite wave or seaward, is very easily determined. The quantity of water that will impinge against the face of this pier is proportional to the perpendicular, therefore the strength of the velocity of the same angle of inclination. The quantity of motion or power with which the wave will flow in the direction parallel with the face of the pier, towards the opposite line of the wave of translation, will be the product of the sine into the cosine of the angle which the work makes with the mean.

Allowing the extreme point and power of forcing the shingle to be west, taking the half of the right angle, the most advantageous is the angle of 45° with this extreme point, and 25° with the main drift of the south-westerly gales.

By this means we shall guarantee the power of the waves in their natural inclination, in passing the beach along this plane, beyond the extreme easterly point of this pier, to the line P, and into the power and force of the wave of translation. * * *

The same rule applies to the waves in-shore and in the main seas; and if the power of the waves or south-westerly winds is sufficiently strong to drive the shingle beaches along the oblique plane, explained on the plan, near the shore, when in their last effort and approaching dissolution, what will be the strength of the waves in the main sea, traversing their course without interruption, passing the south pier along line P, and being many hundred yards from the opposite shore, lifts the shingle and hurls them as by magic in their natural travelling course to the eastward?

It is very evident that the waves on the incline or oblique plane of this south pier, owing to the regurgitation of the waters, will greatly assist the impetuosity of the waves from the main sea in passing the harbour's mouth. Thus receiving such a curvilinear and additional impetus to the waves, as will tend to pass the shingle along the line P to the eastward. On reference to the plan, and the small angular lines on the west, you will find that those are the natural angles by which strength, and therefore power of transferring the shingle, is obtained by the ground waves. Respecting the power thus gained, and the additional strength thereby added to those waves referred to; many are the theories advanced, and also the suppositions which perhaps do not exist in nature, and of which, even though they might prove true in particular cases, it would be difficult to demonstrate their reality, and it is unnecessary for me to solve all the problems that might be proposed on the motions of fluids.

And although it was essential for the stability of this project that I should examine and carefully prove the accuracy of those hydrostatic laws which govern the motions of the waves on this coast and harbour, yet, perhaps, it is unnecessary that I should trouble you with the formulæ and calculations by which I obtained the results. On review-

ing the whole and total of those results, it must appear sufficiently ascertained, that the velocities of the water, though they may arise from different causes, either from the force of fall or from pressure of the higher waters, have only one law, and that law is proportional to the square root of their heights either actual or effective; that is, they are proportional to the square root of the actual and absolute heights of their section. And when the motion of the surface is perceptible, they are proportional to the square roots of the actual heights, augmented by the heights due to the velocity of the surface waves.

The south-westerly winds causing violent waves to raise their surface and falling back at an angle of repose; this principle being established, the height of the water and the figure of the wave being ascertained, it follows as a mere matter of calculation as to their powers. However, they completely prove, without a shadow of doubt, that the velocities of the waves are actually as the square heights of the column of pressure; and the differences usually discovered in experiments are to be ascribed to resistance and other fortuitous causes.

Under these circumstances the result will be to obtain sufficient power to drive the shingle beyond the harbour's mouth. * *

I am also bound to believe that the whole shingle will be passed beyond the harbour's mouth. Indeed the reverse would be contrary to the laws of nature, *and it is my duty, in the improvement of this harbour, to study nature, and by art to imitate her.* I will now do so, and will prove that such is her course by referring to a fact in this harbour, which is, the construction of the large eastern groyne, and the result there explained by nature when her hands are left untied.

This groyne being constructed of very great height and length, the shingle, as a matter of course, gained on the west, and exactly in proportion as the shingle filled on the west, it was excavated on the east; (and I have no doubt that if the storm had not capsized the groyne, the waters on the east would have soon gained through the shingle bank.)

In proportion as the waves were interrupted on the west, exactly did the foaming seas and the regurgitation of the waters add impetuosity on the east side; the overplus of shingle coming round the point was transferred along the line of prevailing winds, and did not reach the shore until many thousand feet eastward of the groyne. No shingle whatsoever was formed along the east side face nor the east of this groyne; indeed it was agreeable to the dictates of nature that there should not.

As that supreme law must be obeyed, that wherever you infringe upon the watery world by increasing the beach on the west, exactly in proportion will the watery world increase on the east by diminishing the beach, and those laws fulfilled: "Thus far shalt thou go and no further."

Here at this groyne you have the great laws of nature on a miniature scale;—the waters interrupted in their course, by the beach collecting on the west side, were thrown with additional impetus to the east side, exactly in proportion to the obstruction caused on the west side, and after several and repeated assaults against the east side of the groyne by the furious waves, at last was undermined, and in the storm of January this year was completely overthrown.

From the above you may infer that no shingle can accumulate at the harbour's mouth. * * * * *

The practicability as well as the utility of this south pier, being thus established in passing the beach shingle to the eastward, I shall proceed to describe the office of the extension pier marked Z.

This pier must be carried so far seaward as to overlap the head of present east pier. The position or direction of this pier is the principal part to be attended to, that is, in conducting the backwater to sea. The south pier being the conductor of beach past the harbour's mouth, no shingle will enter the harbour, and the back water will not have the shingle to return seaward and form a "bar."

Any person who attentively registers the position, and also the periods at which the oar is formed at this harbour, will have the fact fully established, that the extent of the bar is diminished in long calms and summer seasons, and that it augments rapidly during storms.

Certain it is, that at high water, and when there are waves, the position and figure of the bar is discerned by the form which the ground waves impress upon those of the surface, which become short, and sometimes broken, in passing over. In storms, the tumultuous foam from the breaking of the waves marks out the bar; but in calms, as there are then no surface waves, nothing at high-water indicates the danger. Hence the practice of pilots at this port, in taking soundings at low-water.

Thus, when there is an immense supply from the west, the shingle enters the harbour, and in proportion is returned by the backwater on the bar. If no supply comes from the westward, the backwater only operates on the surplus left inside, and that surplus is diminished in each tide, especially if the wind be northerly; the supply outwards on the bar is diminished also, and if it continues long calm, the bar will almost entirely disappear.

But in a river such as the Adur, composed of so many different strata in her bed and banks, the variation of the winds, and the possession of so much backwater, tidal and effluent, as above three millions of tons, will at all times bring down more or less alluvial matter, rough sand, and shingle in suspension; but this backwater being sent seaward obliquely with the line of coast, no bar can possibly be formed. The water will, with all matter in suspension, go alongside of the superior power and pressure of the sea, waves and currents, as if hand in hand with nature. Both going in their natural direction and course eastward, no collision takes place; but both going the same way, in lieu of a war with each other, will assist each other, until the backwater, with matters in suspension, is exhausted, and disappears in the vast ocean.

The direction of this pier is south-east, and the backwater will thereby be conducted seaward obliquely with the more powerful waters of the main. This direction, I conceive, is already arranged and planned by nature, and it only remains for me to assist nature, and by art to second her endeavours to direct and regulate the course the backwater is ebbing. * * *

There is sufficient backwater to guarantee that no bar could form if properly conducted in its natural direction seaward, as proposed by me to construct the proposed extension of the western pier.

I maintain that this is the natural and proper direction, and not in a direct angle with the shore. I will illustrate my arguments thus:—Suppose a man was to have a gun in his hand loaded with a ball, a powerful target is placed rectangular with his line of aim,—he shoots the ball, and the moment it reaches the target it drops down. If the man were to increase his charge five-fold, the ball may traverse the distance much quicker, but so long as the target is the strongest, so certain will the ball (though its velocity has increased) fall down prostrate at its feet.

The same effect is produced exactly with the shingle in the formation of the bar. If sent immersed in the backwater rectangular with the coast, an increase in the velocity of the backwater will avail nothing, so long as the sea is its superior, as before explained in this report. Another effect will be produced by reversing the question. Suppose if the same ball, with the same velocity, was shot at an obtuse angle with the face of the target, the ball will glide from the face, and soon be able to maintain its position, as if nothing had retarded its progress. The same way exactly will be produced in sending the backwater in an obtuse angle with the main and superior power of the seas.

Take another example:—Suppose a carpenter drives a wedge directly into the face of a large piece of timber, he very soon finds his labours useless, and his wedge dropping down into pieces; but if he places the wedge obliquely, and gets alongside of the piece of timber, he will very soon find, that although his wedge is the weakest, yet he gains ground, and at last will raise a greater power than the wedge itself.

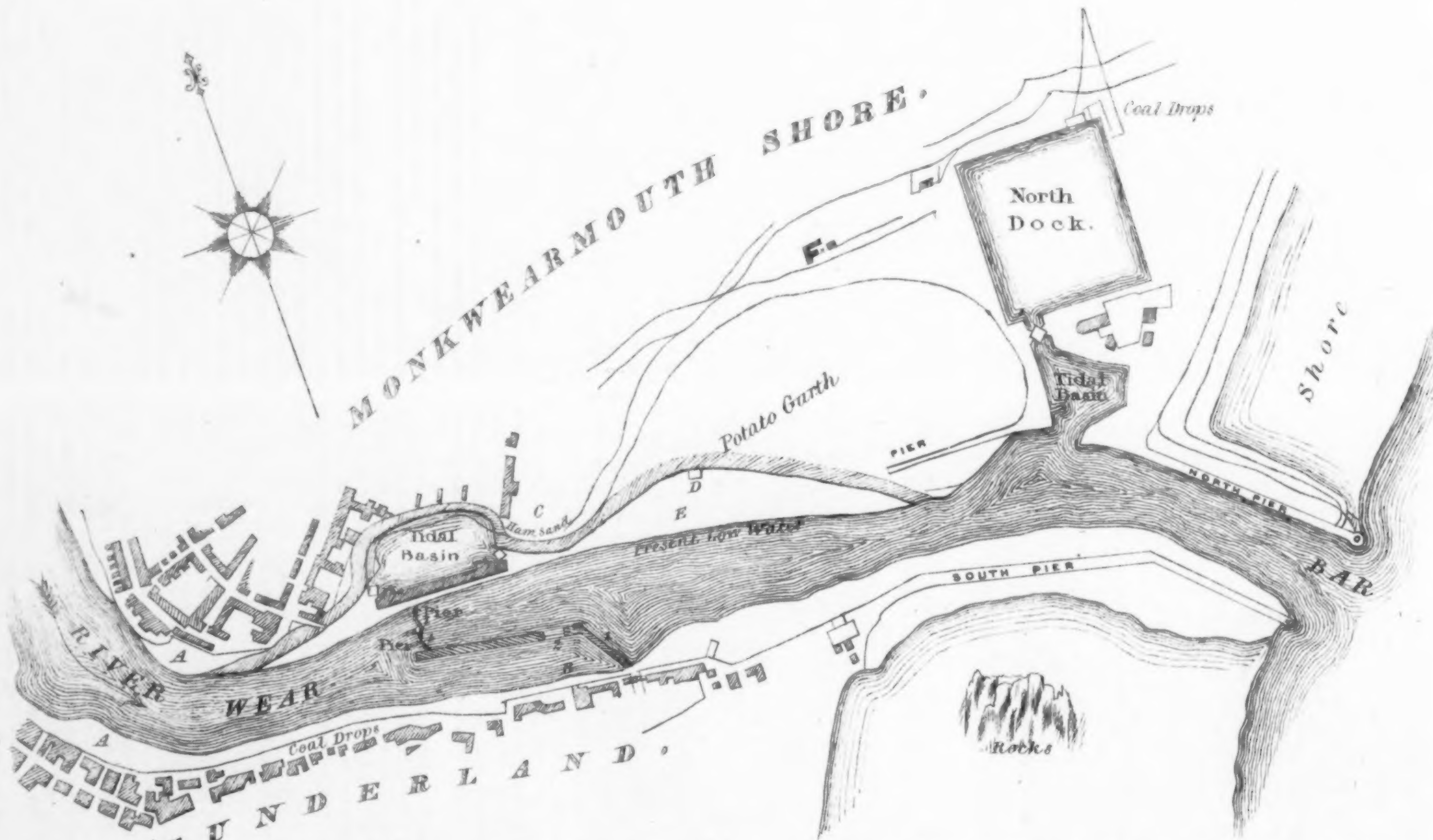
And until this principle be acted upon at this harbour, in conducting the backwater in the form of a wedge alongside of the superior power of the sea, no good will be done, but a "bar" will at all times be formed. * * *

There is in the possession of William Holmes, Esq., of Arundel, documents of very ancient dates, referring to the outlet of this harbour many hundred years ago. Those documents prove that the outlet of the river Adur was at the present low marshes between Worthing and Lancing, and most likely, that owing to this circumstance the old inhabitants of this town connect the valley called Anchor Bottom with the old harbour.

Later documents refer to the outlet being further eastward, opposite the town of New Shoreham. In the course of time it worked its way eastward another mile, and we find piers constructed by a former act of Parliament at Kingston-on-Sea.

Afterwards, as if indignant to be controlled by man, we find by the

PLAN OF THE PORT & PROPOSED FLOATING HARBOUR, SUNDERLAND.



III. Flood Gates. 2. Tumbling Bay. A. Ferry Boat Landing. B. Thornhill's Quay. C. Ham Sand. D. Proposed Line of Deep Water. E. Proposed Deep Water. The above exhibits the River as at Low Water, from the Ferry Boat Landing to the Bar.

T. Faulkner, lith.

history of Sussex, that the outlet to sea found its way to the parish of Adrington, six miles eastward from the first-mentioned embouchure. It further seems, by a plan made by Mr. Desmaretz, in the year 1753, that the entrance was at the above-mentioned place.

The late Mr. Rennie was of opinion, that the natural entrance was at the extreme point eastward; for in his report on this harbour, in 1810, he says:—

"That had the entrance of the harbour been placed at the *natural entrance*, where it was about the year 1750, three miles and a half to the eastward of Shoreham, instead of Kingston-by-Sea; and had the shoals between the mouth of New Shoreham been removed, this harbour would have maintained its entrance, and be in a much better state than it is now."

After the old entrance at Kingston was destroyed, the mouth of the harbour was left to its natural inclination, and travelled gradually home again, having moved, from the year 1760 to 1800, about 1400 yards; but about the latter year was making progress of about 100 yards per annum. This fully proves that the natural outlet of the backwater is eastward; but there is another natural reason why the effluent waters should at this harbour be conducted eastward: because the tidal current of the coast runs to the eastward the first half-flood, and the latter half-ebb; thus, when the action of the backwater is most powerful, if conducted eastward, it will run in its natural course, assisted by the tidal current, which is travelling the same ground.

Another *and a most important reason is*, that the prevailing winds, acted on by violent and furious seas, which are mostly loaded with shingle, travel the course obliquely to the eastward.

I am anxious to press on your minds that the eastward is the natural course of the backwater. It is my duty, as well as yourselves, to imitate nature, and by art endeavour to guide her in the natural path. I am certain that the position laid down in the accompanying Plan, for the direction and construction of the extension pier, will, by being pointed to the eastward, conduct the shingle immersed in the backwater seaward, and that no bar can form.

I have now solved the question of the mode of shingle travelling, and I hope satisfactorily proved the true mode of the formation and existence of the bar; that is, in having the piers of equal length, in admitting the shingle into the harbour's mouth, and sending those shingles immersed in the backwater rectangular with the line of coast. Reversing this system, by assisting the shingle in their natural travelling course past the harbour's mouth, and sending the backwater in its natural course eastward, and obliquely with the line of mean seas, *we shall guarantee a permanent free entrance to the harbour.*

THE REPORT OF JOHN MURRAY, ESQ., C.E.,

TO THE COMMISSIONERS OF THE RIVER WEAR, PORT, AND HAVEN OF SUNDERLAND, ON THE REQUIREMENTS AND PROPOSED IMPROVEMENT OF THE PORT.

Trade of the Port.—Coal is the staple commodity of the port of Sunderland, and its export amounts annually to 1,300,000 tons, which is gradually on the increase. Its foreign trade is also extensive, and great quantities of timber are imported for ship-building, colliery, and other purposes. More ships are annually constructed there than in any other English port. It has rapidly advanced from a mere fishing village, to be the fourth harbour in the kingdom, as respects the aggregate amount of its tonnage; and from the building of slow sailing colliers, to that of mercantile ships of the largest class. Manufacturers have also sprung up to an almost incredible rate in the locality, and have flourished with all the other branches of the commerce of the port. The united towns of Bishopwearmouth, Sunderland, and Monkwearmouth, contained, at the last census, nearly 60,000 inhabitants.

River and Harbour Commissioners.—The conservators of the river Wear and port of Sunderland are a numerous body of the most influential landed proprietors, coal-owners, ship-owners, and merchants in the neighbourhood; and have been intrusted with their important charge by several acts of Parliament, since the time of George I. Certain dues have been collected by them on the shipping frequenting the port, and on the coals exported from it. These funds have been appropriated in carrying into effect extensive works for the improvement of the river Wear and the harbour of Sunderland; and which consisted chiefly in deepening the shoals, the removal of rocks and other obstructions, and the building of piers at the mouth of the river.

State of the Harbour in former Years.—In the year 1809, the average burthen of vessels belonging to the port was about 150 tons; a large ship being then reckoned 250 tons burthen, and which, after taking in two-thirds of her cargo in the harbour, had to cross the bar, on account of the deficiency of water, and take in the remainder, while lying at anchor in the roads, from flat-bottomed keels.

Even a few years ago, it was only at the top of the spring-tides when there was sufficient water in the channel and on the bar to allow vessels of the ordinary size to leave the harbour; and if the weather happened at that time to be boisterous, in consequence of easterly gales, the spring tides passed over, and the vessels had to wait till the next. Numerous ships have been thus detained, and the harbour has been crowded to a very great extent, causing many of them to take the ground in their loaded state, in very awkward positions, and some of which have in consequence received considerable injury. It has been calculated by one of the largest ship-owners of the port, that from the above cause, the average loss could not be less than from one to two per cent. on the capital invested. The actual amount of damage sustained by the shipping, cannot, however, be ascertained, as some of the damaged vessels were not insured in the harbour, and no account is therefore kept of them; but the agents of the various shipping policies of the port state that £8,000 per annum have been paid for such repairs.

Works of the Commissioners.—The Commissioners of the river Wear have for many years paid particular attention to improving the channel, and deepening the bar. They consulted that eminent engineer, the late Mr. Rennie, and his plans were to prolong the piers with solid masonry into deeper water. The north pier is now completed to the full extent, and the south pier has been also lengthened, but it is considered advisable to let it remain as it now is, to see the result, from altering the other pier. The most beneficial effects have been produced by the adoption of these plans: the channel has been straightened and deepened by dredging, and the bar has been lowered and kept in a stationary position by the judicious direction of the piers. There is now about 4 feet of water upon it in the fair way at low-water of spring tides, or 18½ feet at high-water of ordinary spring tides, and about 22 feet during equinoctial spring tides. Great facility is consequently afforded to vessels entering and departing from the harbour, and ships drawing from 15 to 18 feet now cross the bar with greater safety than vessels of half that draught of water could do previously to such works being executed; indeed, ships of 350 tons burthen are now in the habit of going to sea, drawing 14 feet of water, at dead neap tides.

Railways of the Coal-owners and their other works.—It is only within the last 30 years that railways have been brought into general use for the transport of coals from the mines to the sea-borne shipping. Formerly the whole of the coals were taken from the mines to the most contiguous stations on the banks of the river, where they were transferred from the waggons into flat-bottomed keels. These navigated the river in great numbers, and conveyed the coals to the harbour, where they were cast by manual labour on shipboard. The frequent turning of the coals caused much breakage, and depreciation in their value, and the proprietors were thus induced to abandon the transfer of the coals into keels, and to bring the waggons directly to the harbour by longer railways, from whence they were discharged at once into the hold of the vessels. The keels have therefore gone greatly out of use, and are only continued by a few of the collieries in the upper part of the river, where difficulties exist in bringing the railways directly to the harbour. Large sums have consequently been expended by the coal proprietors in the formation of railways, and procuring stations with valuable machinery for their shipping staiths on the banks of the river, in and adjoining to the towns of Bishopwearmouth, Sunderland, and Monkwearmouth. In conjunction with the Commissioners of the river, the late Earl of Durham and the Hetton Coal Company, within the last six years, have expended £13,242 in widening a very contracted part of the river above the Rector's Gill, and excavating the rock from the bed of the river by means of coffer dams, to a depth of from 10 to 12 feet at low water, to give increased facility to the shipment of coals. A considerable sum of

money has also been expended by the Durham and Sunderland Railway Company, in deepening their shipping berths.

The Shipping of the Port.—The shipping of the port may be said to be confined to the channel of the river from near its mouth for a distance of two miles upward. At the beginning of the present century, its shipping was of an inferior class and small tonnage. The vessels were strongly built, and so constructed as to take little damage when lying a-ground; but the rapid increase of trade, and the improvement of the port, has caused numerous ships to frequent it, ill adapted to withstand the strains to which they are necessarily subjected. The vessels now belonging to the port are chiefly of a large class, and of such a description as to make it extremely probable, without further improvement, that they will sustain great damage by straining and lying badly when a-ground.

Plans of Wet Docks.—Various plans for the formation of wet docks have been brought forward at different times by engineers of professional eminence. A residence of upwards of ten years at Sunderland has afforded me the means of judging what are the exigencies and requirements of the port, especially as my professional avocations have engaged me in taking that charge over the river, the duties of which in other ports devolve upon a principal harbour-master and surveyor. The subject of docks has been frequently brought under my notice, and the following are my opinions thereon:—

Mr. Jessop's plan for a Wet Dock.—The late Mr. Jessop suggested the idea of excavating the shallow ground, called the Potato Garth, near the mouth of the harbour, and enclosing it from the river by means of a wall parallel to the south pier. It is evident that a large space might there be obtained for wet docks. But the disadvantage attending its conversion into this useful purpose was very great; as this receptacle has been conceived to be of essential use in allowing the waves during stormy weather to expand and break themselves upon it. If enclosed, the range of the sea would naturally run up the confined channel of the river, and prevent vessels from making use of the lower part of the harbour. The Commissioners have therefore, with the advice of the engineer appointed by the Admiralty, always attempted to prevent the slightest encroachment upon this valuable receiver.

Mr Stevenson's Plans.—I shall pass over other designs made by various individuals from the time of Mr. Jessop, to those of Mr. Robert Stevenson, of Edinburgh, who in 1829 was specially employed by the commissioners to report on the subject.

He projected several works:

1st. A dock on the north side of the river formed partly upon the Potato Garth, above alluded to, which, though not so objectionable as Mr. Jessop's design, would still have been injurious.

2nd. A dock on the sea shore, on the south side of the river; the estimate for constructing which, without going into further detail, was much greater than the trade of the port could afford.

3rd. The conversion of the lower part of the navigable channel of the river Wear, from the Old Low Ferry to Southwick, into a Floating Dock, and forming a tunnel for the passing of the flood and ebb waters through the high ground of Monkwearmouth. The estimated expense of this work amounted to 233,260*l.*, the interest upon which would have caused so heavy a tax upon the shipping as to drive it elsewhere.

4th. A smaller portion of the river at Southwick was proposed to be enclosed by dams with locks, and the formation of an open cut from the Patent Ropery to the Hetton Staiths; the estimate for which was 165,622*l.* This projected dock was too far from the town, and on the opposite side of the river to the principal collieries to be of much use, and it was considered that great difficulty would be experienced in getting a sufficient number of vessels to sea in one tide from a dock so distant from the bar.

Mr. Giles's Plan.—Mr. Giles, in the year 1831, projected an extensive dock along the sea shore in front of the town moor, with a tidal basin, locks, and other outlets communicating with the river Wear through the yards of the Commissioners. The project was carried into Parliament, and after a long discussion it was thrown out by a Committee.

Mr. Brunel's Plan.—Mr. Brunel, at the same time, projected a dock on the low ground, on the north side of the river, northward of the north pier, communicating through it with the river, and by continuing the dock to skirt the high ground and the Potato Garth, he proposed an upper communication with the river at the Ham Sand. This project was also carried into Parliament, and after passing the House of Commons, was rejected by a Committee of the House of Lords.

Mr. Murray's Plan.—In the early part of 1832, I laid before the Commissioners a scheme for converting the lower reach of the harbour into a wet dock, with tidal basins attached. Advantage was proposed to be taken of the bend in the river at the Ferry Boat landing, and thus obtain an area of about 24 acres. It was proposed to make the navigable channel through the opposite town of Monkwearmouth nearly in a straight direction from the bridge to the mouth of the river, by which the scouring power on the channel and on the bar would have been increased. The estimated expense of carrying this undertaking into execution, including the purchase of property and buildings upon it, amounted to 200,000*l.*

Messrs. Walker and Rennie's Plans.—The Commissioners in the latter part of 1832 called in Mr. James Walker and Mr. George Rennie to give designs for a small dock on each side of the river, capable of extension as the necessities of the port might require.

The sites chosen by these engineers were nearly the same as those previously adopted by Messrs. Giles and Brunel, but the details of the plans were somewhat different. The estimated expense of carrying even the designs for the small docks into execution was 184,810*l.*

The Commissioners deposited these plans in Parliament, but they abandoned the north side dock in consequence of a wish expressed by the original proprietors to carry out the plans themselves under the sanction of a charter, and they were obliged also to abandon the proposed dock on the south side by being served with the notice of an injunction from the Hetton Coal Company and others.

Mr. Brunel's Plan carried into Execution.—A dock designed by Mr. Brunel of eight acres, with a small tidal basin attached, and communicating with the river Wear near its mouth, has been since carried into execution by a private company on the north side of the river, on the low ground northward of the north pier.

A railway has been also formed to connect it with the Brandling Junction Railway, and by means of it with some collieries on the northern side of the river, which bring their coals to the dock for shipment. It is therefore useful to vessels which enter and take in their cargoes there, and for vessels lying up during the months of winter. Even with the accommodation of this dock many vessels are compelled, however, to be laid up during the winter months in the river out of the fair way, where they are exposed to injury by straining, chafing their bends and quarters, with other wear and tear. At the breaking up of winter they are, of course, necessarily exposed to the action of the floods and ice. In the month of January, 1841, the ice broke up suddenly and came down the river with great impetuosity, tearing away the moorings and setting the ships adrift upon other vessels, which in their turn were swept away, whereby dreadful destruction of property ensued in one night.

Comments on a South side Dock.—To meet the requirements of the port, a dock to be generally useful must be connected with the southern side of the river, which is the chief seat of trade, and where the principal railways are in connection with the adjoining coal mines.

Various objections may be urged against a dock on the sea shore on the south side of the river, nor would an excavation from the contiguous Town Moor make it any better.

1st. The expense of constructing a dock there of any extent to be practically useful would require the shipping to be taxed with dues far exceeding what they now pay in the neighbouring ports for the accommodation of lying afloat.

2nd. If made, a large additional sum of money would necessarily have to be expended in bringing the railways to the dock. The staiths and machinery now in use would also have to be abandoned, which would sacrifice much valuable property, and the alteration of the seat of trade, from one place to another, would injure in a very great degree the long enjoyed privileges and property of the merchants contiguous to the shores of the river and present harbour.

3rd. The position of the dock along the sea shore would expose the shipping in it, during a dense fog in the case of war, to the attack of the enemy's rockets and shells, which, if thrown into a dock

so situated, filled with shipping during the period of low water, would undoubtedly do incalculable damage.

Comments on the Conversion of the River into a Dock.—The three contiguous towns of Bishopwearmouth, Sunderland, and Monkwearmouth, are built on both banks of the river, which are either naturally steep, and in some places precipitous, or made so by the deposit of ballast from the shipping; consequently it would be very expensive to make any cut for the passage of the waters of the river, in the event of converting the present channel into a dock, either according to the plan of Mr. Stevenson of Edinburgh, or that of my own in 1832, where the cut proposed by me, though much shorter than the other, and not through such high ground, is yet covered with streets and buildings. A better acquaintance with the locality than I had in 1832, causes me to form an opinion that some other plan must be adopted than the formation of any cut through the town of Monkwearmouth. The foregoing are the sites which have hitherto been pointed out for wet docks, and the difficulties attendant on carrying out the designs have been chiefly the cause of their non-adoption.

Deepening of the present Harbour.—It may be proposed that the river Wear may be deepened in a similar way to the Clyde at Glasgow, and thus afford additional berthage to laden vessels, and keep them afloat, without penning up or impounding the water. But a great part of the bed of the river in the lower part of the harbour is composed of limestone rock, the removal of which would be a work of time and cost much money. The quays throughout almost their whole extent are also very indifferently built, with masonry of an inferior description, and have their foundations at and in many cases above the low water mark. They were constructed many years ago, when the harbour was nearly dry at low water; and they are in no way adapted for a tidal river so improved as the Wear. If any greater deepening be attempted, the whole line of quays on each bank must be rebuilt, (not being worth underpinning,) and many of them have warehouses and other buildings resting upon them, so as to increase materially the expense of their renewal. The dredging machines now in use by the Commissioners for deepening and maintaining the existing state of the harbour, seldom approach nearer than sixty feet to the quays on each side. By working more closely they would be greatly endangered, and in some instances they have actually been brought down; but such work has been done only at the request of the proprietors themselves, who took the risk and responsibility of such a proceeding. Any increased deepening therefore of the harbour would be attended with a greater outlay of capital than the port could afford, and a large expenditure would also have to be incurred annually to maintain it.

Peculiarity of the Coal Trade.—The coal trade of the Port of Sunderland is of a peculiar nature, and is carried on in vessels of various tonnage. On account of the uncertainty of the winds, these frequently arrive in large fleets, each vessel requiring the loading of its cargo, and fitting out to sea as speedily as possible for another voyage. A stranger would be surprised at the stream of ships tugged by steam boats passing out of the harbour, about the time of high water, if the wind be favourable for a London voyage, or if easterly winds prevail for a few days. It is very doubtful, therefore, whether any increased accommodation would be given to the trade by wet docks, in consequence of the delay and detention of passing so many vessels in one tide, throughout locks either directly from the river, or from a tidal basin. To obviate this difficulty as much as possible, the vessel should be allowed to pass at once from the river into the wet dock through openings, the gates of which should not be closed till some time elapse after high water, and they should likewise be opened again some time before high water for their egression. Locks, which are so useful generally, are here inapplicable, except for the admission of light vessels, when the other gates are closed; for the laden vessels would always leave the dock at the time of high water, in order to cross the bar with the greatest depth of water upon it.

Proposed Conversion of the River into a floating Harbour.—From what has been stated above, it will appear that there is nothing new in the design of converting the lower part of the river Wear into a floating dock; but the idea of admitting the flood tide through the navigable gates, and allowing the ebb to run through them also for three hours after high water, retaining the latter part of the ebb for the purposes of scouring the channel to sea and the bar, has never yet in this country been carried into execution. This project is now brought forward by the Commissioners under my advice. They have made the necessary arrangements for applying to Parliament during this session for an act to enable them to carry the same into effect.

The following are the leading features of this projected improvement:

The lower part of the river Wear, forming the present harbour of Sunderland, is proposed to be converted into a floating dock, by placing a wall of masonry, with a waste weir and flood or sluicing gates, together with piers, and navigable gates between them, running diagonally upwards and across the river, from the high Coble Slip to the Folly End, and from that downwards to the sand point called the Ham Sand, enclosing a tidal basin on the northern side of the river, as is shown more particularly in the accompanying plans. These works are intended to pen up or impound at least seven feet of water above the present low-water mark of spring tides at the Folly Point. One hundred acres of water will thus be rendered available to shipping, producing at Pallion a depth of five feet in the channel there, and in the vicinity of the gates an average depth of twelve feet, which is considered sufficient to afford every facility for moving ships in and out of the berths at the different coal staiths, and to keep the laden vessels afloat, thus saving the great damage above noticed.

Navigable Gates.—Two openings are proposed to be formed for navigable purposes, each to be eighty feet in width, with skeleton gates placed in them, containing sluices or slackers for more easily shutting them, or letting off the water when required. These gates are proposed to be left open till three hours after high water, or when the water has half ebbed, there being then at spring tides seven feet above the present low-water mark. Ample time before closing the gates will, therefore, be given for ships passing outwards. The gates, it is intended, shall remain closed till the tide flow again to the level of the impounded water of three hours flood, when the tidal water will force them open, and the navigation of the river will proceed as at present.

Tidal Basin.—It is also proposed to construct a tidal basin for the accommodation of steam tugs and other vessels, which may enter the harbour even at low-water, if there be a sufficient depth on the bar. By this arrangement, it is evident, that although the large gates would be closed for six hours, yet the navigation of the river, in reality, could not be considered to be interrupted; for only very small vessels, and that but seldom, would enter or depart from the harbour after the large gates were closed, and these would only have to encounter a detention of, say from ten to fifteen minutes, to fill the tidal basin with water, and make it act like a large lock. From that basin, vessels, and even boats, could pass either singly, or when ten or more sail have collected together, through an opening at the Folly End into the floating harbour. No difficulty would be experienced about the supply of water to fill the basin at all times, and as there would always be lock-keepers on the spot, the only alterations from the present state of things would be as above stated, a slight detention, in point of time, to the small craft.

The tidal basin may also be rendered available (by placing a pair of gates to point inwards at the Folly Point) for the reception and security of fine-bottomed vessels, in case it should be necessary from any accident to the large gates, from extraordinary freshes, or other unforeseen causes, to keep them open during the whole of the ebb tide.

Gates for Scouring Purposes.—On the closing of the large navigable gates at half-tide, the water on the outer side would continue to ebb away, while it would be rising on the upper side of them. As soon as the penned-up water would rise to the top of the gates, or the level of high-water mark of ordinary spring tides, say an hour or an hour and a half before low-water, the sluices would be opened, and an immense scouring power would thus be obtained, which would deepen the channel outwards, and lower the bar at the mouth of the harbour. Some may be of opinion, that scouring a channel by means of sluices only creates irregularity in its bottom, tearing up all before it immediately below the sluices, and depositing the sand and other matter wherever the current loses its velocity. This might be the case in a sinuous stream, but the proposed scouring power at Sunderland would act upon a stream diverging but slightly from a straight line, and a very limited distance from the bar. A large volume of water would be passed down the channel with great velocity, and the matter thus raised by the increased force would be held in suspension until

the agitation of the stream would be lost, far beyond the bar, in the tide passing along the coast.

Widening and Deepening the Channel below the Scouring Sluices.—It is proposed likewise, previously to the opening and working of the sluices, to dredge away a large portion of the shallow ground called the Potato Garth, and to excavate the present low-water channel in the vicinity of the sluices, to a considerable depth, whereby all the sand and gravel would be removed. The space so excavated is proposed to be filled up for a few feet in depth by a covering of large stones thrown in promiscuously, and roughly packed, if thought necessary, by means of the diving bell, and which, from their gravity, would not be acted on by the water from the sluices. A permanent and regular depth would thus be maintained, doing away with all fear of sand banks near the harbour's mouth.

Alluvion and other Deposits in the Harbour.—Objections have been made to the proposed scheme, on account of the sediment which comes down the river, and which might ultimately silt up the harbour. In answer to this, the river Wear may be called the drain of no very extensive tract of country, in a high state of cultivation; much of the interior is in pasture, and consequently the river, although frequently swollen by heavy rains, yet brings with it very little alluvion in comparison with the Humber, the Avon, and other rivers. The deposits, therefore, are very trifling. In corroboration of this, the excavation made in the year 1839, by Mr. Philip Laing, at the salt grass at South Southwick, has, notwithstanding its being out of the stream and in still water, only received an accumulation of mud, on an average over its whole extent, of 2¼ inches, that is, very nearly an inch in depth per annum.

Again, two of the large floating vessels or docks, used for the reception of ships in undergoing repairs, are moored alongside of the quays, in the middle of the harbour, and these vessels are occasionally removed to get the mud excavated from their berths. The one alongside of the north quay, when last removed, had an accumulation of mud beneath it of about sixteen inches, which had taken place during an interval of two years, the vessel being completely out of the stream, and in a place exceedingly liable to silt up. The deposit underneath the other floating vessel is ascertained to be considerably less, and much of the deposit arises in both cases from the cleansing out of the chips and other rubbish, which, careful as the shipbuilders are, necessarily get washed out from the interior of the dock, and find a resting place beneath the vessel.

A test of the nature of the deposits in the harbour is obtained from the works of the dredging machines. Sand constitutes the great bulk of what is raised. During freshes, when the water is in a muddy state, much of the suspended matter is brought in again by the flood, the greatest part of which is deposited below Hylton, four and a quarter miles from the bar, and where the flood current ceases, the rise there being only felt by the swelling of the land and sea water. Sand banks are, in consequence, formed only below that place, and which are in their turn carried downwards by spring-tides and future freshes, causing the deposits in the lower part of the harbour.

The removal of these sand banks causes continual work for two dredging machines, belonging to the Commissioners, and with their powerful assistance the river is maintained in its present state.

It is evident that if sand be brought in by the flood tide, the navigable gates being proposed to be shut during three hours, will exclude a considerable portion of it, which will, in some degree, compensate for any increased alluvion that might be deposited in the river by land floods. If alluvion be deposited, which is very doubtful, it must first take place at the upper limit of the impounded water, and there form mud banks which, before they could accumulate in extent and height to be washed downwards, could be removed at little cost by a small dredging machine.

It may be here remarked that the sills of the gates and sluices are proposed to be laid six feet below the present low-water mark of spring tides, and which being below the bed of the river, would, with the under-current, carry off much of the mud and other matter from the sewerage of the town, the exposure of which at present is so offensive and unhealthy.

Breaking up of the River Ice.—Another objection made to the conversion of the river into a floating dock is the jeopardy in which the hipping would be placed by the sudden breakage of the ice after a evere winter. On consideration it surely must be evident that the danger would be materially diminished, if not altogether removed. The great damage which generally occurs in the breaking up of ice is occasioned by the velocity of the stream about two or three hours before low water, and the impetus with which it carries along with it the floating ice, striking the vessels with violence, breaking them adrift and tearing up the moorings. All this would be prevented by the proposed works, for the flood and other gates would give a command over the velocity of the current, which might either be checked or increased at pleasure, and the whole of the floating ice might be brought down smoothly and without injury to the shipping into the impounded water of the harbour, from whence it might be passed to sea through the gates and over the tumbling bay gradually, without the risk of causing damage to the vessels in the harbour.

Width of the Openings of the Projected Works.—The width of the several openings of the projected works being equal to the breadth of the river at the Folly Point immediately above, and to the breadth between the piers below, near the harbour's mouth, could create no interruption to the passage of the ebb and flood waters, consequently there could be no dread of flooding the lands and other property above the proposed works.

Utility of the Lateral or Flank Walls.—By the arrangement of opening the navigable gates wherever the flag is hoisted on the pier, indicating the water on the bar at half-flood, ships might pass up the river without interruption, and if they took the harbour sooner they could pass into the tidal basin, and be locked into the floating harbour. A fleet of vessels, with an easterly gale of wind, frequently takes the harbour close after each other, and if the leading ships meet with any interruption as the harbour is at present, damage is the immediate result by running into each other, breaking bowsprits, and doing other injury. Under the proposed plan, in similar circumstances, the lateral or flank walls, furnished with bollards or posts, would afford great facility for the immediate dropping up and removal of ships, as there would always be men on the piers at such a time, having a connection with the shore by bridges over the tumbling bay and flood gates on the south side, and by the tidal basin gates to the north. By running a rope away to these posts a ship might be checked gradually, and without any risk of damage, through the large navigable openings into the harbour. These lateral walls would therefore be found exceedingly useful; making the south wall longer than the other, with the intention of founding the sluicing gates on the rock, and thus save the expense of an apron, which is so liable to be undermined. Ships might likewise bring up in an easterly gale of wind, by dropping their anchors all the way, from the present dock entrance to the proposed works, a distance of 600 yards, and as the channel immediately below them is intended to be deepened and considerably increased in width by excavating a portion of the Potato Garth, additional room would be given to prevent their running foul of each other. Vessels instead of dropping their anchors might also, as at present, bring up by beaching on the Sand Point, which it is proposed to maintain.

At night a red light might be exhibited from the eastern extremity of each of the lateral or flank walls, and a bright white light from the centre pier between the navigable gates, so that even in foggy weather it would scarcely be possible to steer a vessel in a wrong course.

Range of the Sea within the present Harbour.—The re-building of the north pier in a more judicious direction than the old one, as respects the run of the ebb tide and its effect upon the bar, has allowed the waves, during stormy weather, to have an increased power upon the canch or shoal which has existed for many years between the piers near the harbour's mouth, and this canch is much lowered in height and reduced in width; in consequence the waves in stormy weather do not break upon it so much as they used to do. The channel upwards has also been greatly deepened and straightened, and the interior shoal or canch, extending from the engineer's house upwards in front of Thornhill's wharf, has been excavated by dredging, and made into deep water berths. These works have increased the range of the sea within the harbour, and difficulty is now felt in securing the vessels lying alongside of the quays in the lower reach. Two timber jetties have been lately erected by the Commissioners to break the range of the sea, and with some beneficial effect, but the undulation is not entirely destroyed.

It has been proposed to the Commissioners to make the solid part of the north pier westward of the present dock entrance, of open tim-

ber framing similar to the western portion, with the view of allowing the waves sooner to throw themselves upon the Potato Garth, and by rolling there to be broken before they reach the Sand Point. Again, it has likewise been proposed, that in place of erecting more jetties as breakwaters on the south pier, a certain part of it between the lower coble slip and the engineer's house be removed, and set back in an angular direction, so as to make the pier form a small triangle, the apex of which would be about 70 yards south from the present line of pier; and to excavate the space between the old and new walls as a receptacle for the waves, which, hugging that pier, would throw themselves upon it and be broken.

Cost of the projected Works.—The cost of this essential improvement to the port of Sunderland is estimated at £60,000, and if an act of Parliament be obtained in this session, the works may be so far executed, *without interrupting the navigation*, as to bring the dock into use by Christmas, 1844.

(Signed) JOHN MURRAY.

Engineer to the Commissioners of the river Wear, port, and haven of Sunderland.

6, Norfolk Street, Strand, London, Jan. 9th, 1843.

Approved and sanctioned by us, the deputation appointed by the said Commissioners to wait on the right honourable the Lords Commissioners of the Admiralty,

(Signed) JOHN SCOTT, Chairman.
C. BRAMWELL.

THE REPORT OF WILLIAM CHADWELL MYLNE, ESQ.,

TO THE COMMISSIONERS APPOINTED FOR THE PRESERVATION OF THE RIVER WEAR, AND THE PORT AND HAVEN OF SUNDERLAND.

GENTLEMEN,

HAVING received instructions through Mr. Murray, your engineer, to report, in conjunction with Mr. Rendel, upon a plan for effecting certain improvements in the harbour of Sunderland, and having been unable, from the pressure of business, to make my survey at the period at which Mr. Rendel could attend, I proceeded on the third of the present month to survey the same, attended by your engineer, and to examine the several plans prepared by him for the proposed works, copies of which have been transmitted to me.

During this survey, I was made acquainted with the objections raised against the projected scheme, particularly as to its effect to seaward of the intended dam and gates; also on the general drainage of the river, and the action of the water on the wharfs of the river, where it is intended to be stalled up to the half-tide level of a spring tide.

Many fears must, no doubt, suggest themselves on the introduction of a scheme upon so large a scale, which has never before been executed in this country, although works corresponding in their object, and in the main features of the design, are in perfect operation on the Continent, under far less favourable circumstances.

In consequence of the numerous rivers which exist, and are supplied by the aggregate quantity of rain falling abundantly on this island, we have rarely been called upon professionally to construct harbours where a sufficient natural back-water does not exist.

The harbours on the Eastern Coast of Kent and Sussex have called forth great consideration, and also large expenditure; but their main objects have been that of refuge during bad weather for commercial vessels, as also for ships of war.

It is perfectly evident, that where a commanding back-water does not exist, and the shores, like those of Kent, Sussex, and Norfolk, be loaded with travelling beach, or where much alluvial soil is brought down the rivers from above, the gradual decay of every harbour so circumstanced must inevitably follow, unless artificial means be applied either by scours or by the application of dredging.

The expence of the necessary works for creating such artificial power, for the maintenance of harbours, has generally been found in this country greater than the value of their locality; and the decay of those, where such artificial means have been adopted, (several of which we have on record,) has no doubt taken place from the circumstance of a sufficient amount not having been laid out to effect the required scour, and not from any defect in the mode adopted.

The silting up of the river Dee, near Chester, is a strong instance of the operation of nature, where the back-water is insufficient. Wells Harbour is another instance. Wisbeach, the Yare, and the Clyde, were in a similar state of decay, until reclaimed by artificial works. The ancient Bay of Lowestoff has been gradually reduced. The harbour of Rye, and various others, exemplify this principle.

There are some few in England almost entirely maintained by artificial means alone, viz., Bridport, Ramsgate, Hartlepool, and Dover.

On the other hand, when we inspect the adjoining coast of France, Belgium, and Holland, we have the most striking instances of what can be effected by art. Here necessity has led to the introduction of works which answer most efficiently the objects desired, viz.: that of scouring away the bar, and in maintaining a sufficient depth of water within the port; many of these being constructed with a very small supply of fresh water, and others depending wholly upon artificial tidal reservoirs for the scouring power, viz.:—Cherbourg, Havre, Fecamp, St. Valery, Dieppe, Boulogne, Calais, Dunkirk, Gravelines, Ostend, Flushing, and Hellevoetsluis.

If, therefore, such effects are in actual operation at the ports above mentioned, from causes so well understood, surely no other argument is required to support their application in the present instance, than to show the value of maintaining the locality of Sunderland as a port, and that the means proposed to be adopted there, although varying somewhat by impounding the water at half tide within the river, yet corresponds sufficiently to ensure a beneficial result from the proposed works, on the principles established in the ports above referred to.

It is hardly necessary for me to state, that great competition has existed of late years in the coal trade; that it has lowered the price of that article in the London market, and that the shipments, through the means employed, have been fully equal to the demand of the increased population; to effect this, very large sums of money have been invested in the formation of railways leading to the port of Sunderland, and in the erection of new staiths and machinery on the banks of the river Wear; and that unless increased facilities are afforded for the shipment of the coals with greater convenience, and in vessels of larger tonnage, much private, as well as public, injury must ensue by the consequent migration of the trade to other ports, to which the shipbuilding interests will also be transferred, to the great injury of the port and town of Sunderland.

The particular feature of the proposed scheme consists in its impounding the lower portion of the river, for six hours, to the depth of a half spring tide. It will thus form a dock within which that class of shipping resorting to the port will be enabled to receive their cargoes while afloat at any period of the day, the previous portion of the tides being appropriated to the passage of the homeward and outward bound ships through the navigable river gates.

By this operation the bar and the channel, to seaward of the gates, will be deprived of a portion of its scouring back water to such an amount as will be impounded in the river after the gates are closed, amounting to about 20,000,000 cubic feet.

To compensate for this loss, a large portion of the tidal water having passed up for the distance of nine miles, will not have had time to have found its way back before the closing of the gates will take place; this will, as a matter of course, be enclosed above the dam, and from levels taken simultaneously at different points on the river, will amount, together with the current flow of the river, to about 15,000,000. This body of water will be available for sluicing purposes, in the usual way; and from its increased current being discharged under a greater head, will operate most forcibly, and produce a greater depth of water on the bar.

It is an admitted fact, that where the velocity is doubled, the effect of the scouring power will be quadrupled; it therefore follows that a much greater force will result from the discharge of the smaller quantity under an increased head, in a less period of time, than is now derived from the flow of the larger amount.

As regards the various objections which have been raised, I see little ground for their existence. A work, such as is now proposed, cannot be carried out without interfering in some degree with private interest, and each individual will consider himself specially aggrieved; but from the general arrangement adopted, and the natural form of the shores, I cannot conceive that any injury will

be occasioned by the increased level of the water during floods, which can only occur under the peculiar circumstance of a fresh taking place at the period of the equinoctial spring tides; but this, with good management, would produce no material injury, situated as the property generally is above the range of such tides.

I should here observe, that several of the shipbuilding slips will, no doubt, be affected, and that pumping engines must be erected, to throw the impounded water out of them after the vessels have been docked. These are but small inconveniences, when compared with the great advantages to be obtained.

As to the possibility of the river silting up, above the dam, it is wholly improbable, as the navigable river gates are to remain open for six hours during each tide, thus permitting the scouring power of the tide to exert its whole force on the bed of the river, for that period.

This will effectually remove all accumulations that may take place during the intervals at which they remain closed, such accumulations being considerably diminished by the gates remaining closed during the first quarter's flood; it being a well-known fact, that the greater mass of silt is brought into the harbour by the indraught of the tide.

The artificial scour outwards may also be occasionally increased, when the diminished traffic in the port will admit of the navigable gates being shut at an earlier period; thus increasing the quantity and force of the discharging waters.

As regards its influence on the lower portion of the harbour, I cannot imagine that the dam will interfere with the customary usages thereof, for the larger classed vessels cannot enter the port until the tide has acquired full 10 ft. 6 in. over the bar; about which period it will be level with the impounded water above; the gates will then open, and the flood tide will continue as heretofore.

The openings through the dam being proposed to be made fully equal to the sectional area of the river, above and below its situation, no increased velocity will be produced; but as the navigable river gates, for the use of the shipping, are narrower than the river, some little delay may be supposed to be occasioned in the passing of the vessels; but as one opening is to be appropriated to the vessels departing from the harbour, and the other to vessels entering, no interference with each other can take place, as is frequently the case at present; and, at all events, no serious inconvenience can occur, as there will be ample time for the passage of all the shipping before the gates are again closed; and indeed, the smaller craft will be passed through the tidal basin after the navigable river gates have been shut.

The width proposed for the openings of these navigable gates being 80 feet each, will do away with all fear of vessels being injured, or blocking up the passage.

As to the effect and mode of controlling the scour, the examples on the French coast, and in your immediate neighbourhood at Hartlepool, are such as sufficiently to negative all apprehension of failure on these points, provided a sound and hard floor be laid for a short distance below the scouring sluices, from which it will be directed, through a channel on the bar below.

The effect of the swell upon the large navigable gates at the dam, during heavy gales from the eastward, will no doubt be considerable, in the existing state of the lower harbour, and measures must be taken to correct the evil effect during stormy weather.

There may be various opinions upon the best mode of effecting this; but it appears to me, if a space of several acres was formed, by throwing back the western end of the south pier, and excavating a portion of the land in your possession, part of which is occupied by your yards, &c., and other parts now lying waste, the swell would, by such means, be intercepted before it reached the upper coble slip; and it might also be desirable to increase the head of the south pier, extending it northward, thus moderately reducing the entrance; by this, the waves which hug this pier would be much reduced, and ultimately destroyed in the excavated portion above recommended; and on the north side it would be so much broken by forming more openings in the existing carcasses, through which it would be discharged upon the Potato Garth, that little or nothing of its effects could then be felt in the river above.

It is to be observed, that the *lowest moorings* are situated about 150 yards eastward of the navigable gates, and it is *below these moorings* where, during gales, vessels bring up, either by beaching upon the *Ham Sands*, and by passing up the harbour, or by dropping their anchors before they reach the Ham, and swing round by the tide; ropes are then run ashore, or to the vessels in the tiers, and their anchors being weighed, they are thus checked, and either drifted into the harbour, or taken away by steam tugs. It thus appears to me that the position of the proposed works will not interfere with the customary operation exercised by the larger class vessels, while the earlier admission of the smaller craft will be under more favourable circumstances than at present, from the water in the harbour being comparatively *freed from indraught*. Still further advantages may be given to the larger vessels, by extending the beaching ground on the north side, and also on the south, and excavating the Potato Garth, so as to give an extent of deep water for swinging room in the outer harbour, far beyond the wants of the port.

Another objection has been raised to the necessary expenditure on those ruinous wharf walls, situated above the proposed dam, which, at this time, are dilapidated, and only serve the purpose of the present shore, and are under constant reparation; but it is well known that a permanent work is ultimately the cheapest, and the impounded water must tend to support the weight of the material employed for the protection of the shore, and also of the bank itself.

Four quarterly periods are mentioned in the bill, of six days each, for the purpose of repairs; but this may be extended as the convenience of the inhabitants shall demand.

The great improvement in thy value of the banks of the river, which must inevitably follow, when appropriated by the proposed works, as quays for shipments, with deep water in front, is such as to require from their proprietors rather the support of the measure than opposition.

Attention will be required during the discharge of those freshes, which take place, when the breaking up of the ice, after a continued frost, is attended with heavy rains; these occurrences are rare, but their effects material.

On such occasions great injury to the shipping is at present sustained from their taking the ground at low water, at which time should the fresh descend, its velocity is increased by the great declivity towards the sea, and also from the reduced sectional area of the river during the last quarter's ebb. Thus the descending torrent, together with the buoyant ice, is forced against the shipping while aground, causing infinite injury, and driving them from their moorings; so soon as the swell raised by their obstruction impounds sufficient to set them afloat, they are consequently forced against each other, and in some instances, as in 1841, carried out to sea.

Much of this inconvenience will however be removed by the vessels being always kept afloat, and from there being a greater sectional area in the upper harbour for the passage of the ice and water to seaward.

Great attention must at this time be paid to the sluicing gates, to give free vent to the flood, which, if done with care, will prevent all obstruction.

Having thus treated on all the points which appear to me essential in the present state of the inquiry, I beg leave to subscribe myself,

Your obedient humble servant,

WILLIAM CHADWELL MYLNE.

New River Head, London,
April 29th, 1843.

SUNDERLAND HARBOUR.

MR. MURRAY'S REPLY TO MR. JAMES WALKER, ADDRESSED TO JOHN SCOTT, ESQ., AND THE DEPUTATION OF COMMISSIONERS OF THE WEAR.

GENTLEMEN,

HAVING been funished with a copy of Mr. Walker's Report of the 27th of April last, giving his opinion of the plan now before Parliament, for the improvement of the port of Sunderland, I consider it due to myself and the situation I hold, to endeavour to correct some of the representations stated by Mr. Walker, arising out of the conflicting evidence brought before him during his investigation.

The disadvantages of the insufficient depth of water in the harbour are universally acknowledged; but the Report states that Lord Dur-

ham and the Hetton Company have improved their shipping places above the bridge at considerable cost, and at those places there is sufficient depth at low-water close to the wharf. The shipping berths belonging to the Earl of Durham are the best in the harbour, and the three highest were deepened, at considerable cost, by excavating the rocks to the depth of twelve feet below low-water, under my recommendation and superintendence. The Hetton Company's lowest shipping berth was similarly improved, but the others are very frequently silted up, and sometimes nearly dry at low-water. Mr. Pemberton's shipping berths, on the opposite side, are even in a worse position. One of the dredging machines is generally employed above the bridge for maintaining a depth of water in these different berths. The shipping places belonging to the Durham and Sunderland Railway Company have from four to ten feet at low-water at spring tides. This depth has been obtained at considerable cost, by the removal of a stratum of strong marl, two to three feet in thickness, resting on the limestone rock; and therefore it is impossible to excavate them deeper than they now are, without incurring a large expenditure.

According to my observations for the last ten years, the ice, as stated in Mr. Walker's Report, neither comes down the river Wear "in great quantity," nor "with great velocity," except on very extraordinary occasions, which may possibly happen once in twenty or thirty years. Generally speaking, it comes away very easily and in small pieces, through the harbour of Sunderland, which is caused by a large body of tide-water breaking up, and carrying it to sea during the latter part of the ebb. The river below Hylton is scarcely ever frozen, and in very severe winters, only for a short distance below that place. Between Hylton and Biddick, which is within the influence of the tidal waters, the ice is broken up, generally speaking, before the river is free above, and is brought down by the ebbing waters without difficulty. The Durham ice, as it is called, always passes through the harbour of Sunderland very much broken, and does no injury whatever to the shipping. This broken ice, from the higher parts of the river, before it can get to sea, may meet with the flood tide, and be carried back by it some little distance; but it does not accumulate to any mass, nor does it freeze again to any extent, when within the influence of the tide.

Even at the breaking up of the ice in January 1841, which was an extraordinary occasion, the mass of ice coming down the river grounded on the shallows at Pallion, and accumulated there, impeding the descending waters until they increased to such a height as to float off the ice, and carry it downwards. This never would have happened had the ice not taken the ground; and it is proposed by the projected works, to impound the water so as to have five feet upon the shoals at Pallion, which will prevent the ice from stopping there. In place of coming down the river, therefore, with the velocity due to the current, from half ebb to low-water, the ice will be floated into the impounded water standing nearly at a dead level, so that its impetus will be completely lost before it can reach the shipping, which, by lying afloat, will allow it to pass beneath them, and spread itself over a wider surface. There is a great likelihood, also, of the ice disturbing itself over the salt grasses of the river, above Pallion, caused by the impounded water, than it can do in the present confined low water channel.

Mr. Walker conceives that the pressure against the dam and gates would not resist the impetus of the moving mass of ice and water. If the works be made strong enough to resist the pressure of a perpendicular height of water during the highest tides, accompanied by land floods, surely the ice, which is a floating body, cannot add anything to that pressure, excepting the impetus with which it moves; and I have endeavoured to show that the force of the floating mass will be lost before it can arrive even at the shipping in the higher parts of the harbour, and consequently at a distance from the projected works. The great width of the openings in the dam are fully equal to pass the broken ice under the circumstances described.

Mr. Walker's second objection, is, the difficulty the works will present to the entrance and exit of large fleets of vessels. The crowded state sometimes of the lower part of the harbour, where the shipping all wish to resort, for readiness to proceed to sea, makes the navigable passage very contracted at present, and the works in my opinion are calculated to effect an improvement. Few harbours, at their entrance, have the means of increasing their capability for the reception of a large fleet of vessels like that of Sunderland. Here, at the distance of 350 yards from the eastern extremity of the entrance piers, the river expands, and takes the remarkable formation of the Potato Garth, or shingle bed, now dry at low water, while at the top of the tide it assumes a semicircular form, with a radius of about 80 feet, thus presenting an area of sixteen acres between the Wearmouth Dock entrance and the Ham Sand, north of the present low-water channel. This area has always been considered of great importance to the harbour, for tranquilizing the swell of the sea in stormy weather. A large part of this shoal ground, which is entirely formed of gravel, might easily be removed by dredging, so as to form a deep and capacious harbour, for the reception of a large number of light vessels, that sometimes enter the harbour in one tide. If beaching around be made to skirt this deep water on its northern side, as far westward as the Ham Sand, vessels may be brought up without dropping their anchors, and be then warped through the navigable gates, or be speedily towed up the harbour, by steam tugs, to make room for others to enter, which would, in my opinion, afford ample facility for all the purposes of the port, and be the means of preventing much of the damage and confusion which now occur, when a number of vessels get huddled together, and block up the present confined low-water channel. I differ, therefore, from Mr. Walker, in supposing that vessels dropping anchor opposite to the Potato Garth would, in cases of strong wind, be the rule adopted. I conceive that many of them, being homeward-bound vessels in ballast, would be brought up by beaching, which is frequently done at present, with no injury, on a floating tide, and with less inconvenience than dropping anchor. Steam tugs, which are much used at Sunderland, would then take a great number of vessels up the harbour, through the navigable gates, (where the current, it must be remembered, would be no greater than at present,) more easily and with less detention than through the confined passage between the ships as they now lie at their moorings. I annex a plan of part of the harbour connected with this question, upon which are delineated the moorings that have been in use for many years, and the number of vessels which the harbour master permits to lie in the situations specified. The works are also marked in red, on the same plan, to show the proposed altered state of things.

Mr. Walker mentions 13 feet as the depth of water at the entrance before the gates are opened. In this I think there must be some mistake, as there is 4 feet of water in the fair-way on the bar at low-water of spring tides; and the rise of half flood being seven feet three inches, makes only eleven feet three inches of water. Something more should be allowed for the send or swell of the sea, making barely depth enough on the bar for average class vessels, in ballast, at half flood. Those entering with a strong tide, and easterly gale, would require 13 feet on the bar; and with that rise of tide the navigable gates would have been opened nearly an hour.

As to the ships departing from the harbour, there is no scramble, as

described by Mr. Walker. Each generally is towed out, one after another, by steam tugs. The smaller ships seldom leave till half flood; but if inclined to do so earlier, they could do it through the tidal basin, while the large vessels now move out as early as they can to cross the bar with safety; those of the greatest draught remaining till nearly the time of high-water.

The third objection of Mr. Walker is the danger of sand collecting behind the gates, and thus preventing them from opening or shutting. Culverts and other means were always intended to be adopted to provide for this exigency. It must be evident, that if the sectional area of all the proposed openings, at the depth mentioned in my former Report, be equal to the present sectional area of the river above, as well as below where they are intended to be placed, they must pass the water of land-floods without obstruction; and as to the injury which the shipping may sustain by taking the ground in case of accidents to the gates and sluices, it is a probability to which all docks are liable: and in practice at Bristol, Liverpool, and other places, it seldom occurs. It is shown on the plan, that the tidal basin is intended to have an additional pair of gates, fronting inwards at the Folly Point, with the view of docking in it a few sharp-built vessels, in case of accidents, or at those periods of the year specified in the Bill, when the waters of the river are intended to be entirely run off. The Wearmouth Dock will also afford accommodation for vessels on such occasions.

I differ from Mr. Walker, who supposes that the "following" waters of the river would be the chief supply for sluicing purposes. By observations taken in different parts of the river on the state of the tide at the period of half ebb, I find that about 33,000,000 cubic feet of tidal water are proposed to be impounded during ordinary spring tides. I further calculate, that with the "following" waters passing down the river in dry seasons, the quantity collected in two hours against the dam and gates available for sluicing purposes, is about 15,000,000 cubic feet. The last quantity being passed through sluices, for the period of an hour below low-water, under an average pressure of seven feet three inches, would create a velocity of the current through the present sectional area of the river, between the piers, at three miles an hour; and as the bed of that section, and the bar 300 yards beyond it, is composed of sand and gravel, it would be acted upon by such increased current, and deepened considerably.

It is also stated, that the swell or range of the sea in the present harbour would cause a rebound from the solid parts of the proposed works, which might be injurious. This may, in my opinion, be altogether prevented; for the sea at present hugs the north and south piers, according to the direction of the wind, leaving the middle of the river, opposite to the Potato Garth, comparatively smooth; and, therefore, by opening a considerable portion of the western end of the south pier, as mentioned in my former report, and making (if it should be deemed necessary) what the French call a *clair voie*, the swell that now hugs it, and passes up the harbour, would be broken therein. If, on the other hand, the North Pier, from the Wearmouth Dock entrance upwards, be made with open framework, and a portion of it be removed altogether, the waves will be lost by expanding on the Potato Garth.

Mr. Walker is of opinion, that by penning the water, and consequently lessening the velocity, the deposit in the harbour would be increased. If the impounded waters were always to remain stationary, as in a wet dock, no doubt sediment would be formed, but the greatest part of the mud deposit would be brought in by the flood tide. The land water which passes through the pents of Dover harbour is trifling, and of a clear quality, even after rain; yet these receptacles are covered to some thickness with the finest mud. Seaham harbour, in our own locality, through which no land water is discharged, has much mud in the docks, which can only be brought there by the tidal waters.

If there were no sluices in the proposed dam, sediment might accumulate in time to its proper surface. Mill dams placed directly across a river, with no contiguous draw gates, naturally cause it to silt up; but where the dams have sluices, even of a small area, and only occasionally opened, the bed is never raised above the sills of the gates. The in-draught of the water to the sluices works upon the bottom, and sweeps all before it. Many cases might be adduced to show their tendency to deepen rather than to silt up the bed of a river.

If alluvion be deposited higher up the river, it could be acted on by the principle of flushing. This method has been successfully practised by the Commissioners of Sewers of the Holborn and Finsbury district; and shows, on a small scale, what can be done on the Wear. By penning back the common run of water, and letting it off suddenly, an artificial fall is obtained, and consequent velocity of the current, which not only scours the sewer for a certain distance below the temporary dam, but removes all above it, within the influence of the penned-up water.

In my former Report it is stated, that the greatest portion of what is raised by the dredging machines is sand, a very considerable quantity of which, with other matter held in suspension, is brought into the river by the first of the flood, which, by its gravity, rolling along the bottom, stirs up the light particles of sand, and carries them along with it, to form deposits on the returning ebb tide. In corroboration of this, it is well known that the flood makes from the north, and sweeps along with it much sand and gravel. Every groin or jetty that runs out from this shore at right angles with the line of coast collects it. The North Pier itself acts like a groin, and has been the means of forming that area of low sandy ground on which the Wearmouth Dock is now placed. The indraught of the tide, when it sweeps round the North Pier, naturally brings with it a quantity of sand and gravel: by shutting the proposed gates, much would be excluded from the harbour, as there would be little indraught during the first half of the flood, and the greatest portion would be carried to the southward. The small quantity that may be deposited in the comparatively still deep water, below the proposed works, would be easily removed by constant sluicing and occasional dredging.

As regards the accuracy of the estimate, I have gone through it in a detailed form, with a contractor of great experience in works of a similar nature, who has completed many large contracts successfully, and is satisfied that the quantities are properly measured, that the prices are sufficient, both as to labour and materials, and that the works described in the plans can be executed in a sound, substantial, and workmanlike manner, for the sum of £60,000.

I am, Gentlemen,

Your obedient servant,

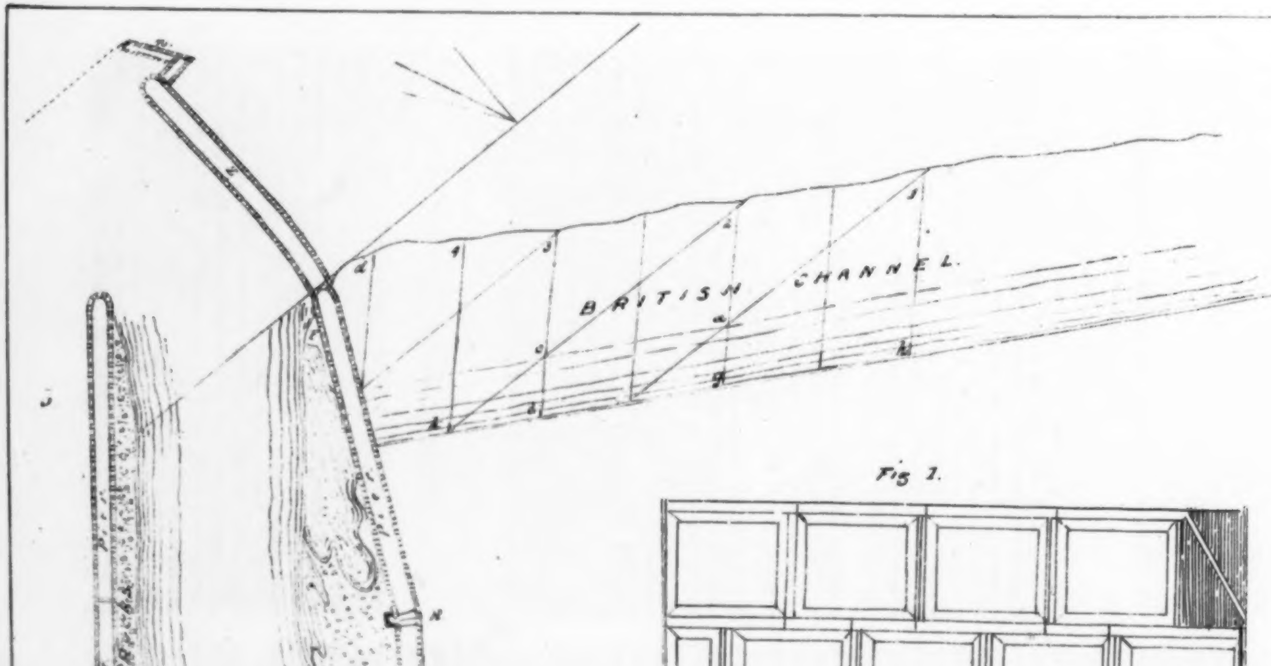
No. 3, Spring Gardens, London, JOHN MURRAY.

May 8th, 1843.

A NEW FORM OF BLOCK FOR WOOD PAVING.

Sir,

In return for the valuable information I receive from your highly talented journal, may I be allowed the liberty of sending you a description of a method of forming wood paving (if the subject is not too stale) superior, so far as I have seen, to any of the very many plans that have been patented. It is simple in construction; the blocks when put together will each rest upon the adjoining ones, both upwards and downwards, thus giving to each a great bearing surface; in



ENTRANCE TO SHOREHAM HARBOUR.

Fig 1.

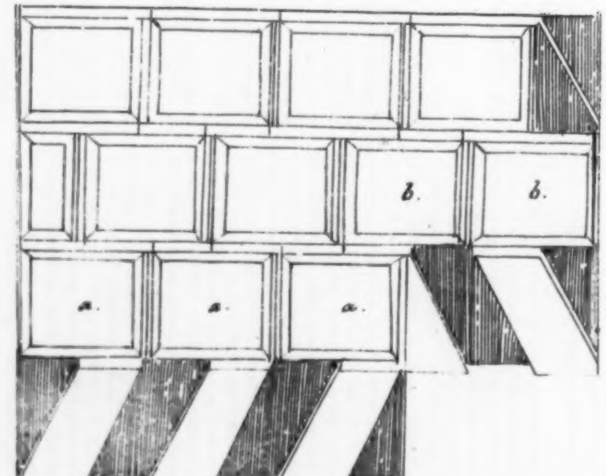
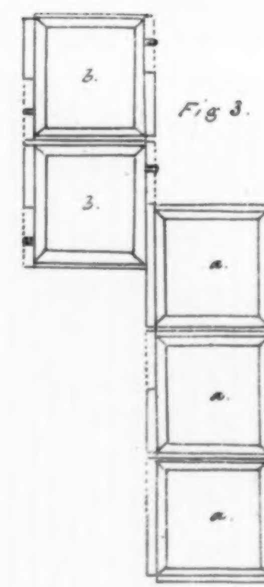


Fig 3.



Figs. 1. 2. 3. WOOD PAVING.

Fig 2.

fact, they lock each other so firmly, that, if well be secured at the edges by good abutments, they will form a floor or roof. They may be used either with or without dowels. They are perfectly self-supporting without dowels; and in this is their superiority over any form of block that I have yet seen. The only objection that can be made to this form of block is the loss of one-twelfth part of the wood, which must be cut away to form the projections and recesses.

They are to be laid in courses, each alternate course to be cut the reverse to the adjoining, as the drawings will show. The grain of the wood being placed in an upright position, must be less slippery and more durable than in any other position.

Fig. 1 is a sort of isometrical view of a clump of blocks.

Fig. 2 is an elevation of two tier, *a a a* and *b b*.

Fig. 3, a plan of the same.

I am, Sir, Your obedient and humble servant,

ALEX. MACGILLIVRAY.

June 7th, 1843.

25, *Princes Street, Cavendish Square.*

A NEW MODE OF DAMMING FOR THE REPAIR OF CANAL BANKS.

TRANSLATED FROM "IL PIRATA."

The inundations which have recently caused so much damage in the provinces of Bologna, Ferrara, and Romagna have been the means of exciting the ingenuity of a distinguished young mathematician of Bologna. He has devoted all his talents to discover, if possible, some means of restraining the floods, caused by the torrents which descend from the mountains, with great impetuosity, after heavy rains and the melting of the snow, loaded with stones, gravel, and earthy matter. The beds of the rivers are raised by the transport of detritus, and the water overflowing our productive lands, breaking the banks, and destroying the hopes, fortunes, and sometimes the lives of our industrious agriculturists.

This mathematician, D. Q. Baretti Filopanti, has found out that a thick piece of canvass stretched upon piles will restrain a current of water, so that the workman, being defended by this shield, can execute such works as may be required to strengthen a bank that is in danger, or to restore a part that has been thrown down.

This invention or discovery being made known to the hydraulic engineer and some of the professors of the University of Bologna, an opportunity was immediately given for an experiment, in one of the trenches of the canal which carries part of the waters of the Reno into the city. A piece of canvass, prepared according to the directions of Filopanti, being fixed, was found to keep back the waters like a perfect bank; and the waters being thrown through a breach cut for the purpose, the populace were admitted to walk in the canal, which remained quite dry. Experience and practical skill will probably contribute hereafter to the more ready application and perfect success of this novel and ingenious invention, for which Filopanti has acquired a right to the public gratitude of his countrymen.

CAPTAIN TAYLOR'S BREAKWATER.

Sir,

It having been announced that the floating breakwater at Dover had broken adrift, without stating that it was an *iron cylinder* breakwater, and having received several communications from parties connected with harbours, I deem it my duty to place before the British people, and authorities presiding over harbours, the various experiments I have made for several years with iron cylinders, airtight vessels, and fixed open frame-work breakwaters, which I was obliged to abandon as useless for the purposes intended, in favour of substantial timber floating breakwaters, constructed from professional observations, founded on nature's unerring laws, in subduing the power of the sea. I took for this purpose the elevation of the beach and rocks exposed to the constant action of the sea, and thus obtained, by experiments, the proper graduation, angle, or inclination, depth and breadth, necessary to overcome the power of the sea, and to abate the undulation, by yielding, in lieu of opposing a fixed solid resistance.

It is well known that a cylinder, whilst it remains air-tight, will merely float to its diameter, so long as it is kept in a horizontal position, and no longer; and when depressed by the weight of its moorings requisite to secure such a solid resistance, or one end lifted up by a sea, cannot sustain the weight of the moorings when its horizontal position is destroyed; consequently, it requires so large a circumference to render it buoyant, to bear the necessary weight of moorings, that it presents too solid a resistance to the violence of the sea; and as it breaks over its round surface in lieu of subduing a wave, increases the force by forming rollers or breakers, which being a translation of a solid mass of water, would augment the agitation. True it is, a cylinder, like a ship's mast, floating in the harbour, would offer some resistance, but a body suspended to it, in motion, will not abate the waves; and that the constant friction, the necessary thinness of the metal, and impossibility of its floating horizontally, render it impossible for it to carry the weight of moorings necessary to secure it, is evident by the late attempt at Dover, and borne out by the repeated trials I had previously made—proving all air-tight vessels useless for such a purpose.

There is something more substantial required, for the smallest air-hole, from imperfection in the manufacture, accidents, friction of the parts, or rapid decay from corrosion of thin iron in salt water, will render it unsafe, and less durable than timber. A cylinder will not afford, when sunk to its diameter (being its line of flotation), the least protection in a gale of wind for boats to make fast to it. Nor could shipwrecked mariners find the least shelter from the constant waves flying over it. A cylindrical buoy, 10 feet long, and of large circumference, every pilot and seaman knows, offers no protection in a gale of wind for a boat to make fast to it, whilst my breakwater, in every acceptation of the word, is a life preserver. After repeated trials I abandoned air vessels, although secured by my patent. I even endeavoured to reduce the size of the cylinder by a frame-work of wood, in order to increase its buoyancy, but it notwithstanding presented too solid a resistance to the sea, and would not carry the requisite weight of moorings. A spar drifting against the cylinder would cause it to sink. I would not incur the serious responsibility of trusting life and property to so frail a fabric, dependent on so many contingencies. A breakwater must afford a safe anchorage at all times; independent of air-tight contrivances, it must be sufficiently buoyant from its own materials, to carry the weight of moorings, without the risk of accidents and continual expense. Each of my sections possesses seven tons more buoyancy than required, with the power of increasing it. The principal mooring chain and timber moorings are secured by passing through the keel, which governs the oscillation—the main beam can be lowered at pleasure to regulate its gravity, and running through the whole length, the strain and bearing are equally apportioned; the friction chains pass through hawse pipes, and will not require to be changed in twenty years, whilst the timber moorings do not add to their gravity. These improved timber moorings are put together by the marine glue; the chains used are passed through hollow timber, preserved also by the glue.

Captain Groves states, in his descriptions of an iron cylinder breakwater, that his sections are to be made fast 6 feet apart. Now, every nautical man must know, with a fall of tide of only 6 feet, cylinders so moored would be dashed to atoms against each other. I take it to be an essential requisite in a projector of floating breakwaters, to possess an accurate knowledge of the force of the sea and tide, to know how to moor it, when so many lives, and such a vast amount of property depend on such a qualification, to lay them securely down; it took me years of practice with breakwaters, after being forty years in the navy, to come to a right conclusion on this important and paramount object. *No air-tight vessel of iron can possess sufficient buoyancy to carry the weight of moorings, without presenting too large a surface to the sea*, and therefore iron cylinders are totally useless for such a purpose.

The late and present Board of Admiralty granted anchors and mooring-chains to lay down my breakwater, but the directors of the breakwater company did not obtain their charter, and cannot, therefore, carry it out. Admiral Sir G. Cockburn, and other distinguished officers and scientific men, did me the honour to become patrons of my humane invention; and Captain Pechell warmly advocated it at Brighton. It is acknowledged to have opened a new era in the formation of harbours of refuge.

The improved breakwater is formed of substantial frame-work of

timber, rendered buoyant by cork, and put together by Jeffrey's patent glue. The principle upon which this invention acts so efficiently is simple, and carries conviction with it, even to minds the least scientific; it yields to the force of the sea, instead of opposing to it a fixed solid resistance—such as a cylinder. The open framework admits the sea to pass through it, breaking and dividing its masses, and rendering them comparatively harmless. The timber moorings do not add to its gravity, and, by the improved plan of mooring, it yields—so that the inert water within and to leeward receives the shock of the sea—thus making the very element the resisting medium, with little strain to the moorings or frame work. The whole being put together with Jeffrey's glue, and rendered sufficiently buoyant by cork—the acknowledged preservative marine glue bids defiance to worms or decay, and will be guaranteed to last as long as stone-work; indeed, if a section were taken to pieces, it would, for marine purposes, sell for the cost of the timber, as this preparation hardens by time under water. It may, then, be justly asked, who would incur the responsibility of advocating air-vessels of iron, which decompose in salt water, so liable to accidents, and would not be of any value hereafter; whilst timber so prepared is sufficiently buoyant to carry the necessary moorings?

A French patent having been secured in France for my improved breakwater, with cork and Jeffrey's glue, and improved moorings, I was invited to meet the Ponts et Chaussées, to explain my humane invention. The French government have shown me every courtesy, and it redounds to their honour in the cause of humanity to be the first to form harbours of refuge on this plan, so beneficial to the commerce of the world. The first harbour is about to be constructed on the Mediterranean shore; it was but recently a British man-of-war was lost at Marseilles, and the late lamentable shipwrecks on the French coast appeal to the best feelings of the humane heart in behalf of shipwrecked mariners. The meritorious acts of the king of the French to improve the commerce of France, and at the same time making every inlet and dangerous anchorage safe asylums against the storm, to prevent those dreadful catastrophes which every winter all nations have to deplore, must be universally hailed with delight.

The French government having all their harbours under their own management, trials of my breakwater were ordered at Marseilles, and the result was their unqualified approbation. The model was submitted to the Ponts et Chaussées, the most eminent engineers and savans of France, I might perhaps have said of the world. I had the honour to explain and answer the numerous questions propounded by these eminent men—I say the honour, for I felt it to be so, to receive their unanimous opinion of its utility, and perfect adaptation to the humane purposes intended, the construction of harbours of refuge for the preservation of life and property; and I feel it the more, because a distinguished French admiral introduced an iron cylindrical breakwater similar to the one tried at Dover. It was abandoned, from the reasons before stated, and other cogent proofs of its utter incapability of subduing the power of the waves; whilst mine has been ordered to be laid down to form harbours of refuge at Marseilles or Cewtal, and the moorings, with an improved breakwater, has been constructed under my superintendance at Limehouse, to be forwarded to France.

Captain Sir Samuel Brown, R.N., the projector of chain cables and suspension bridges, gave me a plan of an air-tight breakwater of iron; we compared models, and he in the most honourable manner abandoned his own plan, and recommended £500 from the Pier Company to carry mine, for the formation of a harbour of refuge at Brighton. I hope the government will not form an opinion by a trial of the cylinder. I have tried four sections of breakwaters for years, and, after my exertions and attaining acknowledged approval, I do hope I am deserving the support of my own government, although I have been absent on this humane undertaking—I am now busily engaged in constructing breakwater and moorings for a harbour of refuge.

J. N. TAYLER, Cap. R.N., C.B.

London, March, 1843.

PRESERVATION OF TIMBER.

Timber being an indispensable material in all constructions, it has ever been a matter of great importance to give it by artificial means a durability it does not naturally possess. In our own day chemistry has grown to maturity, and it has been the parent of numerous inventions which have severally been brought into favour by their patrons, and enjoyed a greater or less degree of public approbation and support. The clamour of partizans is a great hindrance to the exercise of a sound judgment, and it is difficult among the conflicting interests to ascertain which of the various claimants is most entitled to public support, but it is not our intention to be involved in so tiresome and litigious a question as that of giving a judgment between them. All the evidence which can be obtained to confirm or annul the pretensions of the various patented processes we are happy to receive and present to our readers, free from any mercenary bias towards either one or the other. It is a question in which every man is personally interested, and we only express the opinion of the professions generally when we say, that no discovery would be so valuable to the art of building as that which secured the certain preservation of timber.

Timber is exposed to many sources of decay, but these may all be comprised under two; a natural liability to decomposition, and an exposure to the destructive attack of certain animals. The liability to a change of structure and chemical decomposition may be facilitated by a variety of causes, and they cannot always be determined or foreseen by the architect or engineer. The destruction from animals is peculiar to certain localities, and in this country is almost confined to works constructed in rivers and seas. That which is an effectual preservation under one condition is not necessarily so in another; and we are mistaken if some of the inventors of the present day have not exposed really valuable discoveries to great objection by endeavouring to claim for themselves an universal specific.

These remarks have been called for by some letters we have received upon certain patented modes of preserving timber, used in the present day, which we present to our readers without comment, leaving every man to decide for himself which is most worthy of his confidence.

The Kyan process consists, as every body knows, in the use of the corrosive sublimate, but so much has been said and written upon the subject, that it is not necessary that we should attempt to describe the process, or give the reasons which have been urged for its adoption.

Mr. Bethell's invention, as explained in the letter of our correspondent, consists in the use of the pyrolignite of iron and the oil of tar. It is hardly necessary to inform our readers that nature has preserved wood by these substances for a long series of years, and there can therefore be no doubt as to the propriety of using them for our own purposes. The only question to be decided is, whether the situations in which we find timbers thus preserved warrant us in the belief that the same mode will be equally effective in the situations in which we intend to employ the same materials. We must, however, in all these matters, depend more on judiciously conducted experiments than upon any reasoning by analogy.

Mr. Payne's process may perhaps be called mineralizing vegetable matter, as it consists in ejecting metallic solutions into timber. This also is an imitation of a natural process, except that by art as much is done in hours as nature does in years. The artificial, however, is less complete than the natural, but at the same time the former better serves our purpose, in the present case, than the latter.

KYANISING.

To the Editor of "The Architect, Engineer, and Surveyor."

Sir,

In your Number for May you published a Report to the Treasurer of the Brighton Suspension Chain Pier Company upon the preservation of timber from decay, by Mr. W. B. Prichard, of Shore-

ham; and as the Report and the letter accompanying it contain many misstatements, which if not contradicted may pass for truth, and injure the reputation of a very valuable discovery, you will much oblige me by inserting the following remarks.

1st. It is asserted that sleepers kyanized five years ago, and in use at the West India Dock warehouses, have been discovered to decay rapidly.

I would state in reply, that kyanized sleepers have not been used at any of the West India Dock warehouses, but the Anti Dry Rot Company did lay down at *their own* station, West India Docks, in 1836, some Scotch fir sleepers, prepared with very weak solution, *by way of experiment*, and some of these have shown symptoms of decay.

2ndly. It is asserted that the wooden tanks at the Anti Dry Rot Company's principal yard are decayed.

The tank referred to was made of unprepared wood, as the maker can testify, and was used as a water-cistern, and occasionally held solution: only one or two of the boards showed the slightest symptoms of decay, and that on the *outside* alone. Mr. Prichard, it appears, is not aware that a water-proof tank is capable of containing a solution of corrosive sublimate without waste. The solution will not penetrate timber literally, but only from the extremities, and therefore it is in no way surprising that a tank containing solution of corrosive sublimate should decay on the outside.

3rdly. It is asserted, that in Shoreham Harbour there is a waling piece, the very heart of English oak, kyanized, and in use only four years, which is like a honeycomb or net work, completely eaten away by the *Teredo navalis* and other sea worms.

The truth of this assertion is denied upon the authority of a Minute of Survey and Report from the Commissioners of Shoreham Harbour.

4thly. "I oppose it (kyanizing) on the ground that in tropical climes it would be as poisonous as the quicksilver mines of Illyria."

In reply to this statement, I would refer to Messrs. Enderby of Great St. Helens, who built a ship many years since, wholly of kyanized wood; it has been been three voyages to the South Seas, the crew have returned each voyage remarkably healthy, and we have now in our possession some of the bilge water, which has been analyzed, and found to be considerably more pure than on ordinary voyages.

I am, Sir,
Your most obedient servant,
TASWELL THOMPSON.

2, *Lime Street Square.*

MR. BETHELL'S PROCESS FOR PRESERVING TIMBER.

To the Editor of "The Architect, Engineer, and Surveyor."

SIR,

In the May Number of your Journal there is a paper by Mr. Prichard on the preservation of timber by Bethell's patent, and as the process is not so generally known as it deserves to be, I beg the favour of your inserting the following remarks:—

This mode of preserving wood occurred to Mr. Bethell, I am informed, from the consideration of the means adopted by the ancients for preserving their dead.

The accounts given of it by ancient writers, by Herodotus Diodorus Siculus, Pliny, and others, have been fully confirmed by the late examination and unrolling of mummies by Mr. Pettigrew.

It appears to be now settled that the Egyptians caused the bodies of the dead to be thoroughly imbued with bituminous matter. The whole muscular tissue of mummies is generally found impregnated with this matter. Belzoni observes, "that what does not incorporate with the fleshy part remains of the natural colour of the pitch, but that which does incorporate becomes brown, and evidently mixed with the grease of the body."

There is no doubt but that the impregnation of the bodies was caused by the application of heat.

The great heat applied dried up the juices of the bodies, and also decomposed the tarry matters which had been previously introduced into them, whereby creosote was generated, which no doubt formed the only essential part of the mummifying process. The spices and perfumes used were superfluous, and the various other operations used in the embalments were mere matters of idle ceremony, and were most likely had recourse to, chiefly with a view of mystifying the notions which the vulgar might entertain of the embalmers' secret art.

It appears that the native mummia or mineral tar was used as well as the vegetable. The cedria, or cedrinus of Pliny, which he says was used in Egypt for embalming, unquestionably contained ready-formed creosote, as all oils of tar do, for the process by which the ancients obtained tar was almost identical with our own. This liquid, called cedria, seems to have been prepared from other trees as well as the cedar, for the term sometimes merely denotes that the substance spoken of possessed preserving qualities; but from the great durability of the cedar wood, it was the hieroglyphic of eternity. The leaves and binding of books were often smeared with cedria to preserve them.

It is well known that whatever will preserve animal matter from decay, will also preserve vegetable, and as the excellency of the mummifying process has been proved by the test of ages, Mr. Bethell applied it in the best possible manner to wood.

His invention consists in impregnating vegetable substances throughout with the oil of tar, and the bituminous matters containing creosote, and also with pyrolignite of iron, which holds more creosote in solution than any other menstruum.

The wood is put into a close iron tank, like a high pressure steam-boiler, which is then closed and filled with the tar oil, or pyrolignite. The air is then exhausted by air pumps, and afterwards more oil or pyrolignite is forced in by hydrostatic pumps, until a pressure equal to from 100 to 150 lbs. to the inch is obtained. This pressure is kept up by the frequent working of the pumps during six or seven hours, whereby the wood becomes thoroughly imbued with the tar oil or the pyrolignite of iron, and will be found to weigh from 8 to 12 lbs. per cube foot heavier than before.

With large tanks like those on the Bristol and Exeter railway, 50 loads of timber per day can be easily prepared in each.

The effect produced is that of perfectly coagulating the albumen in the sap, thus preventing its putrefaction, and also of covering the fibres of the timber with a waterproof coating. For wood that will be much exposed to the weather, and alternately wet and dry, the mere coagulation of the sap is not sufficient; for although the albumen contained in the sap of wood is the most liable, and the first to putrefy, yet the ligneous fibre itself, after it has been deprived of all sap, will, when exposed in a warm damp situation, rot, and crumble into dust. To preserve wood, therefore, that will be much exposed to the weather, it is not only necessary that the sap should be coagulated, but that the fibres should be protected from moisture.

The atmospheric action on wood so prepared, renders it tougher and infinitely stronger. A post made of beech, or even of Scotch fir, is rendered more durable, and as strong as one made of the best oak; the bituminous mixture with which all its pores are filled acting as a cement, to bind the fibres together in a close tough mass; and the more porous the wood is, the more durable and tough it becomes, as it imbibes a greater quantity of the bituminous ore, which is proved by its increased weight. The materials which are injected preserve iron and metals from corrosion; and an iron bolt driven into wood so saturated, remains perfectly sound and free from rust. It also resists the attacks of insects; and it has been proved by Mr. Prichard at Shoreham harbour, that the teredo or naval worm will not touch it.

Wood thus prepared for sleepers, piles, posts, fencing, &c., is not at all affected by alternate exposure to wet and dry: it requires no painting, and after it has been exposed to the air for some days it loses every unpleasant smell.

This process has been adopted by eminent engineers, and has been used with success on the Great Western Railway, the Bristol and Exeter Railway, the Manchester and Birmingham Railway, the North Eastern, the South Eastern, the Stockton and Darlington; and lately, in consequence of the excellent appearance of the prepared sleepers after three years exposure to the weather, an order has been issued by Mr Stephenson, that all sleepers hereafter to be used on the London and Birmingham Railway are to be prepared with it.

The expense of preparing the wood varies from 16s. to 15s. per load, according to the situation and distance from the manufactories where the material is made.

For railway sleepers it is highly useful, as the commonest Scotch fir sleeper, when thus prepared, will last for centuries. Those which have been in use three years and upwards, look much better now than when first laid down, having become harder, more consolidated, and perfectly waterproof, which qualities, combined with that of perfectly resisting the worm, render this process eminently useful for piles and all other wood work placed under water; posts for gates or fencing,

prepared in this manner, may be made of Scotch fir, or the cheapest wood that can be obtained, and will not decay like oak posts, which invariably become rotten near the earth after a few years.

AN ENGINEER.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

March 20.—J. Shaw, Esq., in the chair.—A paper "On the contemplated Restoration of the beautiful Chapter House at Salisbury Cathedral," was read, by Mr. T. H. Wyatt, architect to the Salisbury Diocesan Church Building Association. After alluding to the absence of all documents in the Chapter records, which could throw any light on the commencement or early history of this building (though supposed to have been erected soon after the completion of the cathedral, in 1258), Mr. Wyatt proceeded to describe its present condition. It is covered with a low roof, not rising above the parapet, the timbers of which, from being injudiciously framed together, without any lateral tie, resting on a central pillar of wood, carried up from the small shaft that supports the whole of the stone vaulting, have very considerably injured the walls, and have tended to force that centre pillar about five inches out of the perpendicular. The light and beautiful tracery of the windows has suffered considerably from this cause, combined with that arising from the corrosion of numerous iron bars, which are connected with them. The main walls and buttresses are, however, sound and uninjured. The pavement of encaustic tiles, with which it was originally decorated, has fallen into decay: it has sunk, and lost much of its colour. The internal stone-work has suffered much from natural decay; and of the painted glass, which must originally have tended to soften and enrich this light and beautifully proportioned room, not a vestige exists. After some details as to the *comparative* age, beauty, and construction of the other polygonal chapter-houses in England, similar to that at Salisbury, such, for instance, as those at Wells, Westminster, Lincoln, York, and Southwell, Mr. Wyatt proceeded to describe the contemplated restorations. He dwelt with much earnestness on the propriety of restoring a roof of pyramidal form, instead of the low one now existing, the horizontal line of the parapet being opposed to the spirit of that architectural group which surrounds it, and at variance with the practice of the early Gothic architects. The intended roof would be similar in appearance to those at York and Lincoln, the latter having been restored early in this century. There are at present eight iron bars, which surround the top of the central Purbeck marble shaft, and go through the buttresses; they are supposed to have been introduced by Sir Christopher Wren, when he was called in to strengthen the tower, but there is no proof of his having done so; and Mr. Wyatt considered that they must have been placed there long before his time. The great object is to remove these, which so prejudicially affect the appearance of the interior; and, by throwing the whole weight of the new high roof on the eight buttresses (instead of being spread over the walls generally, as at present), Mr. Wyatt believes, that such an additional resistance will be gained to the outward thrust of the groined roof as will enable them to be safely removed; indeed, they do not appear now to have any great strain upon them. The centre pillar it is proposed to take down (the superstructure being firmly shored up), and to rebuild it perpendicular to the centre of the present springer over the column, for which the whole foundation of concrete is well adapted. The external masonry would then be repaired, and the new roof put on; it would be covered with lead, and held together so as not to have any tendency to force out the walls, and the eight iron ties, or bars, which would be then carefully taken away from their present position, it is proposed to introduce above the vaulting and under the roof. The stone capitals and ornaments inside would be repaired, and an entirely new floor of encaustic tiles (strictly copied from the present examples) laid on concrete. The great extent of glass renders it improbable that it can at first be filled with stained glass; that some will be introduced there is, we hope, no doubt, if it is only to serve as an example.

Mr. Ferrey read a paper 'On an old staircase at Tamworth Church which has fallen into decay.' It is a sort of double corkscrew stair, winding in such a manner, that two persons may go up and down without meeting, although both are circulating in the same well-hole. Mr. Ferrey offered some remarks as to its probable purpose. It is said to be a solitary instance of this exact kind of stair in England, but we remember to have seen one at Cologne.

INSTITUTION OF CIVIL ENGINEERS.

Sir M. Isambard Brunel presented a design intended to illustrate the mode of securing the poling-boards of the shield of the Thames Tunnel.

The poling-boards shown in the drawing, he described, as being intended to close the whole area of the excavation in the front, as the side and top staves were intended to secure the sides and top of it.

The shield (weighing nearly 180 tons), in passing over the ground, served materially to compress it, and make a firmer foundation for the tunnel. When it was considered that the mass of ground removed weighed 63,000 tons, while the brick structure by which it was replaced weighed only 26,160 tons; some idea might be formed of the difficulties which had been encountered in the progress of this undertaking.

It would be seen by reference to the early reports, that 540 feet of tunnel had been made in the course of sixteen months, viz, from the 1st of January, 1826, to the 27th of April, 1827. At that period the miners and bricklayers struck, without even securing their work. In this emergency, after standing still a week, new hands were engaged; the result was, that on the 11th and the 12th of May, the ground showed symptoms of giving way, and on the 18th the river broke in and completely filled the tunnel; the length of brickwork then completed was about 550 feet.

He was convinced that no irruption would have occurred but for the desertion of the men, for at no previous period had so much work been done; the average progress being 12 feet per week for sixteen weeks, and having at that time the advantage of his son's services and those of experienced assistants, the work might have continued, and the tunnel would have been finished in about four years.

After this irruption, an advance of only 50 feet was made within the period of the year 1827, and in consequence of a second irruption, the work was totally abandoned.

In the year 1835, after a lapse of seven years, being liberally assisted by the Government, a new shield was provided, and the work was resumed in the beginning of March 1836.

The work, however, proceeded very slowly as contrasted with former periods. On the 11th of June the water broke in and continued to trouble the works for six weeks. Having succeeded in repelling this attack, the progress for the whole year amounted to 117 feet.

Foreseeing that he should, at some future period, have to account for the causes of these delays, Sir Isambard instituted, in the course of the year (1836), distinct sets of records for every branch of the service, afloat as well as underground, in order to place beyond doubt the circumstances which might not otherwise be credited. These registers enabled him to give the minutest details of the work, and would, he hoped, be found useful in any future similar undertaking.

Through the whole of the year 1837, the progress was only 28 feet 4 inches, a rate which hardly exceeded that of a fortnight of the year 1827. Two irruptions took place within the range of eight feet, owing to the looseness of some portions of the strata, which were so fluid, that the only expedient for advancing, was by forcing forward some of the polings with the screws. The frequent bursts of gas at that period, and in 1838 and 1839, had moreover such an effect upon the men, that some of them fell senseless at their post. There was, therefore, great risk of the poling boards falling down, as had been the case before, and causing a total disruption of the ground.

In this dilemma, the expedient of connecting the poling boards with each other by hooks was resorted to, forming by this means a complete panel in the face of each of the 36 cells of the shield; the top poling being suspended to the head of the cell, the panel could not be disturbed even with a cavity in front of it; there was likewise an additional means of supporting the polings, by iron spurs resting upon the floor-plates and going into the ground.

Notwithstanding the apparent increase of labour occasioned by this addition to the poling-boards, good progress was made, amounting to 249 feet in the course of twelve months, and the hooking was found so safe in its service and its results, that were another tunnel to be constructed, Sir Isambard stated, that he would make the system of attaching the poling boards, an essential part of the organization of the shield, being convinced that it might by this means be worked through the worst ground, with a certainty of safety and success.

Description of Mr. Clay's new Process for making Wrought-Iron direct from the Ore; as practised at the Shirva Works, Kirkintilloch, Scotland. By William Neale Clay.

In this communication, the author first describes the various stages through which the metal passes, between the reduction of the ore and its arriving at the state of malleable iron, by the ordinary mode of manufacture; and then he explains the process which he has invented, and introduced practically at the Shirva Works.

By the ordinary system of iron-making, the ores are reduced into the state of carburet of iron, and then, by refining and puddling, the metal is de-carburetted, thus making it into malleable iron by a number of processes, which are recapitulated:—

1st. Calcining the ore.

2nd. Smelting in a furnace, by the aid of blast, either cold or heated, with raw coal, or coke, for fuel, and limestone as a flux.

3rd. Refining the "pig" into "plate" iron.

4th. Puddling, shingling, and rolling, to produce the "rough," "puddled," or No. 1 bars.

5th. Cutting up, piling, and rolling, to produce "merchant," or No. 2 bars.

6th. A repetition of the same process, to make "best," or No. 3 bars.

Seeking to diminish the number of manipulations, by the new process a mixture of dry Ulverstone, or other rich iron-ore (Hæmatite) is ground with about four-tenths of its weight of small coal, so as to pass through a screen of one-eighth of an inch mesh. This mixture is placed in a hopper, fixed over a preparatory bed, or oven, attached to a puddling furnace of the ordinary form. While one charge is being worked and balled, another gradually falls from the hopper, through the crown, upon the preparatory bed, and becomes thoroughly and uniformly heated; the carburetted hydrogen and carbon of the coal, combining with the oxygen of the ore, advances the decomposition of the mineral, while, by the combustion of these gases, the puddling furnace is prevented from being injuriously cooled. One charge being withdrawn, another is brought forward, and in about an hour and a half the iron is balled, and ready for shingling and rolling.

The cinder produced is superior in quality to that which results from the common system; it contains from 50 to 55 per cent. of iron, and is free from phosphoric acid, which frequently exists, and is so injurious, in all the ordinary slags: when re-smelted, it produces as much No. 1 and 2 cast-iron, and of as good quality, as the ordinary "black band" ore of Scotland.

The cast-iron produced from the slag (amounting to one-third of what was originally contained in the ore) is mixed with the ore and coal in the puddling furnace; and thus, while nearly all the iron is extracted from the ore, as much wrought-iron is produced in a given time, and at the same cost of fuel, as by the old system.

The first process, producing puddled bars of superior quality, is consequently on a par with the fourth stage of the old system, as it avoids the necessity of the preceding separate manipulations.

From the absence of all deleterious mixture, by once piling and reheating the rough bars, iron is produced, of a quality in every respect equal, and in powers of tension superior, to that which results from the second piling and reheating in the common mode; it is therefore contended that the two processes produce from the Hæmatite nearly one-third more iron, of as good a quality as is usually obtained by the six processes of the old system.

The iron thus produced bears a high polish, is very uniform in its texture, is ductile and fibrous, having more than an average amount of tensile strength, and at the same time appears to be more dense, as it possesses a peculiar sonorousness, resembling that of a bar of steel when struck. It has also been converted into steel of a good quality.

Mr. Clay contended that the ordinary method of making iron was neither so scientific, nor so practically good as there was reason to expect it would have been, when iron formed so considerable an item in the productive industry of the country. His invention was in some degree based upon the old Catalan fire, wherein melleable iron was produced direct from the ore, although by a considerable expenditure of fuel: by his process the ore was also reduced at one operation into the state of malleable iron, by combination with a large portion of carbonaceous matter; and as the deoxydation of the ore could proceed simultaneously in an adjoining preparatory bed, through which the frame of the puddling furnace traversed, there was necessarily a great saving of time, labour, and fuel in the production of the metal, while the quality was at the same time improved. He argued, therefore, that if the system was generally adopted, a large portion of the capital now sunk in the expensive constructions of blast furnaces, blowing engines, &c., would be dispensed with.

Mr. Taylor observed, that the process appeared to be only applicable to the rich qualities of iron ore, which were now used in comparatively small quantities, as a mixture with the clay ironstones of the coal fields, from which iron was generally produced in this country. There existed large quantities of Hæmatite in Great Britain, equal in quality to that of Nassau, or of the Hartz mountains, from which so much iron was made, for converting into steel. The mines of Ulverstone alone now produce 50,000 tons annually, and at least 25,000 tons more could be shipped from Cornwall; and if a demand existed, there was scarcely a limit to the quantity that could be raised. He apprehended that the iron made by this process could be converted into good steel; this was very desirable, as it would render this country independent of Sweden and Russia, whence nearly all the steel-iron was now imported.

Mr. Heath had examined Mr. Clay's process of iron-making, and found that the wrought-iron produced from a mixture of Scottish pig-iron, and Hæmatite ore, was of a superior quality, bearing severe tests without injury. The iron made by this method, from Indian pig iron and specular iron ore (per-oxyde of iron), from Devonshire, which was identical in quality with the celebrated Elba ore, when converted into cast steel, by a process which he had accidentally discovered, possessed the quality of welding like sheer steel, without any of its defects. The method he alluded to, was to combine manganese with the cast steel in the crucible, and when drawn out under the tilt hammer it could be worked and welded to iron, like shear steel: the consequence of this discovery was, that the latter quality of steel was almost abandoned for cutlery, and the former was now generally used, as it did not exhibit the laminated appearance when polished, which shear steel frequently did. The metal was sounder, and fewer wasters were made. All the brown Hæmatites contained manganese, and there was little doubt that, by selecting the proper kinds of ore, malleable iron might be made in Great Britain by this process, as good for converting into steel as any of the Swedish iron. There was abundance of specular iron ore on Dartmore, equal to the Elba ore, and which would (he had little doubt) produce as good iron as that from the Dannemora ore.

Dr. Faraday remarked, that the process invented by Mr. Clay was founded on sound chemical principles. It was desirable to abandon the use of limestone as a flux: it was proved that the purest limestones contained phosphates, which, although advantageous in agricultural processes, were detrimental in iron making.

Mr. Fox had tried some specimens of Mr. Clay's iron, and found them to bear severe tests, as well as the best cable bolt iron made in the ordinary manner.

Mr. Clay explained that Mr. Heath's process was not indispensable, for converting into steel the iron made by his method; and also that argillaceous iron ores, after calcination, could be treated in his furnace, like the Hæmatite ores, but not so advantageously.

Mr. Taylor said that 25,000 tons of steel were converted annually in this country, and of that quantity not more than 2,500 tons were made from the best Swedish iron; for the remainder, inferior qualities of iron, such as Russian iron, marked CCND, from the forges of Monsieur Demidoff, were used. All that iron was made with charcoal, and could only be called inferior when compared with that made from the Dannemora ore. If Mr. Clay's process was successful in treating the Hæmatite ores, as had been stated, it was of great importance, as it would emancipate the country from a dependence upon foreign products.

He had recently seen in Germany, a process of producing steel by stopping the operation of puddling pig iron at a certain point, or intermediate state between cast and wrought-iron, and hammering the mass at once into bars. The operation was one of much delicacy, and depended entirely upon the skill of the workman.

Mr. Heath believed the manufacture of steel was involved in unnecessary mystery; it was the general opinion that foreign iron was essential to produce good qualities. Iron as now made from coke furnaces certainly contained too much foreign matter to be used for steel, and it would require more attention to the selection of the materials, before pure iron could be obtained; some of the Low Moor iron, the good quality of which was universally admitted, had been made into blistered steel, but although the springs made with it appeared perfect, it was said that they did not answer so well as those made with steel from charcoal iron.

The Sheffield manufacturers required that steel should possess "nature and body;" the first quality to enable it to be rolled and drawn out without cracking, and the second that it might receive and retain a fine edge. Steel made from Garnderria iron (South Wales) possessed "nature," but if made into cast-steel, it fled into pieces in working, as it did not possess "body." Steel from German ores appeared to have "body," but wanted "nature." Steel from Indian iron, although difficult to work, stood better than other kinds when once reduced into form; this he attributed to the purity of the magnetic ore from which it was produced; there was not the slightest trace of phosphorus, arsenic, or any deleterious foreign matter. He was convinced that, with a mixture of Indian pig-iron (which could be produced very cheaply) and Devonshire ore, by Mr. Clay's process, iron could be made of excellent quality for converting into steel at such a reduced price as would render the introduction of Swedish and other foreign iron unnecessary.

Mr. Taylor believed that improvement in the quality of steel, rather than reduction in the price, was the object to be sought. In the large quantity used in the mines under his direction, the dearest steel was found to be the more economical. He had seen as many as twelve dozen borers used to make one blast-hole, and unless the tools kept their points well, the labour of the men was thrown away.

Mr. Giles presented a plan and sections of London Old Bridge, made

from his surveys of it in 1820, by order of the Committee of the Bridge Lands, with descriptive notes.

The plan represents the sterlings, piers, parapets, and roadway of the bridge, its low-water channels, called locks, with the soundings through the locks.

The sections represent an elevation and levels of the sterlings, piers, arches, roadway, and locks, with levels of the tides observed at the bridge in September and October, 1820. The datum to these levels being the Trinity high-water mark of London, which is recorded on a stone let into the lower external wing of the Hermitage entrance of the London Docks.

From the plan it appears that—	Ft.	In.
The aggregate waterway between the piers above sterling height was	524	2
The width occupied by the piers . . .	406	10
Making the total length between the abutments of the bridge	931	0
The aggregate waterway below the sterlings at low-water was	230	11
And the aggregate distance occupied by the piers and sterlings at low-water was	700	1
	931	0

The level of the tides shows—	Ft.	in.	
The extraordinary high-water mark of springs to be	2	0	above datum.
The average high-water mark of springs between 23rd September and 25th October, below bridge	0	6·5	under ditto.
The same above bridge . .	1	2	„
Making the high-water of spring-tides above bridge 7·5 in. under the same high water below bridge, owing to the obstruction which the piers presented to the tides attaining their full height above bridge: and this difference was found commonly to be 8 in.			
The average high-water mark of neap-tides above bridge was	4	3	„
And the difference of high-water of neap tides below and above bridge was not observable			
The average level of low-water mark above bridge was	14	5	„
The average level of neap-tides low-water mark below bridge was	16	6	„
The average level of spring-tides low-water mark was	18	9	„

Thus the average fall of water through the locks of the bridge at neap-tides was 2 ft. 1 in., and the same at spring-tides was 4 ft. 4 in. But an extreme fall of 5 ft. 7 in. was observed through these locks on the occurrence of a high land flood, and a spring-tide ebb.

Having completed the surveys of London Old Bridge, Mr. Giles subsequently took the levels of the tides from thence to Teddington lock, and found that in the absence of high winds and land-floods, the high water of spring-tide on the upper side of London Bridge attained its level or height at all the London bridges, also at Battersea, Putney, Kew, and Richmond bridges, and at Teddington lock.

Account of a Series of Experiments on the comparative Strength of Solid and Hollow Axles. By John Oliver York, Assoc. Inst. C.E.

The author first describes the causes of fracture in railway axles, which he attributes to the sudden strains and injury produced by concussion and vibration. Those resulting from concussion are chiefly ascribed to a defective state of the permanent way, any sudden obstacle opposing itself to the progress of the train, and the severe shocks arising from the wheels coming in contact with the blocks and sleepers when thrown off the line. The force of vibration and its certain effect to produce fracture in a body so rigid as a railway axle, is then fully explained; the evil arises from the impossibility of diverting from the axle the continued series of slight blows or vibrations to which it is subject, or of causing a free circulation of them through its entire length, since the naves of the wheels being fixed tightly on to the axles, form a point on either side for the vibrations to cease, and the particles of iron composing the axle at this point become dislocated by the continued and unequal strain, and ultimately break; the same action is described as taking place in the journal of the axle, and hence the fact that an axle seldom breaks excepting at the journal, or at the back of the nave of the wheel. The twisting strain to which railway axles are subject, is next considered, and a calculation entered into, to prove that upon a circle of only a few feet in diameter, and assuming a first-class carriage on four wheels to weigh 6 tons, the strain resulting from this cause is so slight as to be unworthy of consideration in the inquiry. The paper next proceeds to point out, how and why the hollow axle is better able to resist the strains before referred to, than the solid ones now in use.

First, by the process of manufacture, by which the crystallization of the iron is avoided, and it is left in a better state for sustaining sudden strains and continued action. Secondly, by the position of the metal composing the axle, since the comparative strength of axles are as the cubes of their diameters, and their comparative weights, only as their squares, consequently, with less weight there must be increased strength; and thirdly, that the vibration has a free circulation through the length of the axle, no part being subject to an unequal shock from the vibration, and the axle would therefore receive much less injury from this cause. In conclusion, it is submitted that a railway axle should possess the greatest possible degree of rigidity between the wheels, to prevent it from bending or breaking from concussion, combined with the greatest amount of elasticity and freedom in the particles of iron within the axle itself, to prevent the injurious effects of vibration.

The details of a numerous set of experiments are then given, to prove the superiority of the hollow axle in all these respects, the average of the whole of which is thus stated.

As regards rigidity to sustain a dead weight.

The axles being supported at the ends, and the weights applied in the middle.

Hollow Axle.						Solid Axle.			
Weight.				Deflection.	Permanent Set	Weight.		Deflection.	Permanent Set.
Tons.	Cwt.	Qrs.	Lbs.	Inch.	Inch	Tons.	Cwt.	Inch.	Inch.
7	14	..	6	1-16th	..	7	14	5-16th	1-16th
9	2	..	..	3-16th	..	8	1	3-6ths	5-32nd
9	16	..	..	3-8ths	1-8th				

As regards its capability to resist a falling weight.

5 cwt. 3 qrs. 6 lbs. falling from a height of 16 feet on to the centre of the axle.

Hollow Axle.		Solid Axle.	
1st blow, deflection .	1 1-8th	1st blow, deflection .	1 3-4th
2nd „ .	2 1-4th	2nd „ .	3 1-4th
3rd „ .	3 1-4th	3rd „ .	4 1-4th

As regards the elasticity and fibrous quality of the journals.

Hollow Axle.		Solid Axle.	
Number of blows to destroy journal (average) .	28	Number of blows to destroy journal (average) .	10

Proportions of axles.

	Hollow Axles.	Solid Axles.
Diameter .	4 inches .	$3\frac{1}{2}$ inches
Weight .	1 cwt. 2 qrs. 20 lbs. .	1 cwt. 3 qrs. 24 lbs.

The paper is illustrated by specimens of the broken axles, both hollow and solid, and by diagrams of the mode of manufacturing the two kinds of axles.

Mr. Geach presented a series of specimens of ends broken off solid axles, made by the Patent Shaft and Axle Company, Wednesbury; they had borne severally 886, 148, 293, and 278 blows of a sledge hammer, weighing 38 lbs. before they separated from the body: above twenty more ends had been broken off, the weakest requiring 138 blows. The diameter of these journals was $2\frac{1}{2}$ inches.

An axle was exhibited which had been bent nearly double under an hydraulic press, with a pressure of 64 tons: the journals ($2\frac{1}{2}$ inches diameter), were also bent in opposite directions, by repeated blows of a sledge-hammer, without any signs of fracture being perceptible.

The firm which Mr. Geach represented had made upwards of twenty-five thousand axles, and had tried a very large number by breaking them; they almost uniformly found them of good quality, which might be attributed to the mode of manufacture. Around a centre bar of iron were placed eight bars rolled to a proper form to complete a circle, the joints radiating from the centre; they were then welded together by rolling, and finished under the hammer; the fibre of the iron, it was contended, was thus worked, and remained in its most favourable position.

He was not opposed to the principle of hollow axles, but he wished to prevent any unnecessary prejudice against solid ones, by inferences from any one set of experiments; he would therefore suggest that another

series of experiments should be made between the relative strength of the two kinds of axles, for which he would contribute the necessary number of solid ones.

Mr. York described the manner in which the solid axles had been selected for the purpose of experiment. Having obtained General Pasley's consent to be present on the occasion, he ordered axles from the Patent Axle Company, and another eminent maker, and selected also several other axles supplied by the Patent Axle Company to the London and Birmingham Railway; these axles were new, never having been under any carriage; he contended that the result of the experiments afforded a fair specimen of the axles generally in use, and were such as the public were in the habit of riding upon. The axles which had since been made by the Axle Company, and were then exhibited to the meeting, showed a quality of iron which could not be surpassed: if this was the usual quality made use of by that company, it still more forcibly proved his position as to the uncertainty of manufacturing solid axles, for while one specimen took a great number of blows to break it, the majority of them were fractured by a slight force; it was this uncertainty which he proposed to avoid, and he contended that it was inseparable from the method of making axles described by Mr. Geach, for in passing the faggot through the rolls to weld the bars together, it frequently happened that they were only united to a depth of one-half or three-quarters of an inch, hence it was to a certain extent hollow, and partially avoided the injurious effect of hammering; if, on the contrary, they were perfectly welded, the iron became crystallized, as in any other solid axle: this fact was proved by the specimens before the meeting, those that were solid having been broken by very little force, and the unsound ones requiring a great number of blows to produce fracture.

In the experiments, the hollow axles had broken under a different number of blows, but this was owing to their having been made of larger diameter in the journals than the solid ones (but with only an equal quantity of metal in them), and afterwards turned down to the same diameter, which left them of unequal thickness and too thin for a fair test; still, however, with less metal than in the solid ones, they were stronger; this might be accounted for by the mode of manufacture, as by retaining the axle hollow, the crystallization of the iron was avoided.

The present mode of making the hollow axles, he describes to be by taking two trough-shaped semicircular pieces of iron, bringing their edges together, and welding them under a hammer between swages. He however dissented from the process of hammering, and intended to finish his hollow axles by compression only. This, he contended, would avoid the injury done to the iron by the present mode of manufacture, and that with the same quantity of iron, the strength of axles being as the cubes of their diameters, and their weights only as the squares, a hollow axle must possess considerable advantage over a solid one.

Hollow axles had long been considered desirable, but the expense of making them had hitherto prevented their use; he had reduced their cost by his process to the same rate as the solid ones, and felt confident that in bringing them under the consideration of the profession, through the Institution, they would be fairly treated and ultimately adopted.

General Pasley confirmed the correctness of the results recorded by Mr. York, and the satisfactory nature of the experiments, which had impressed him with a favourable opinion towards hollow axles. It was of importance to avoid deflection, as it was almost as fatal as fracture in causing accidents. After the late accident on the North Midland Railway, he observed a solid axle bent into the form of the letter C, and the upper portions of the periphery of the wheels nearly touching each other. The hollow axles would certainly resist deflection better than solid ones of corresponding weight.

In answer to a question, Mr. York said that the iron was chiefly injured by the amount of hammering which it received in forging.

Mr. Taylor remarked, that the question of the amount of injury received by iron in working, was discussed at the meeting of the British Association, in 1842, and the effects of vibration and electricity had also been treated of by foreign engineers. It appeared to be generally admitted, that the great source of mischief was the cold swageing which the iron received, in order to give the work a good appearance. In order to test this, Mr. Nasmyth subjected two pieces of cable bolt iron to 160 blows between swages, and afterwards annealed one of the pieces for a few hours. The unannealed piece broke with five or six blows of a hammer, showing a crystallized fracture; while the annealed piece was bent double under a great number of blows, and exhibited a fine fibrous texture. The fact of the fibre being restored by annealing was well understood and practised by smiths, particularly in chain-making.

Mr. York could not entirely subscribe to the great benefit of annealing, as he had found that after annealing one end of a hollow axle for 48 hours, it was broken off by 82 blows, while the other (annealed) end of the same axle resisted as far as 78 blows.

In answer to a question from Alderman Thompson, Mr. York said that he had found as much mischief arise from over-heating iron as from over hammering it; but the difference of the appearance of the fracture, indicated immediately when iron had been burned.

Mr. Taylor said that in Mr. Nasmyth's experiments, the over-heated iron was almost as fragile as glass.

Mr. Gravatt believed that vibration, whether caused by the smith in working the iron, or by the use to which the bar was appropriated, was the reason of its fracture, and it was certain that a constant change was going on in all manufactured iron. At the Thames Tunnel the "fleeting bars" used as levers for turning the large screws for forcing forward the shield, never lasted longer than three or four weeks, although they were very strong, and were made from the best materials by careful smiths. They were only used occasionally, and then without any concussion, having only the power of eight men exerted upon them: yet they broke constantly, and the fracture exhibited a bright crystallized appearance. It was found at last, that in order to give them duration they should be left rough, and not hammered much in working.

Mr. Newton observed that full ten years since, Dr. Church had used hollow axles for his experimental steam coach on common roads, being convinced of their superiority.

Mr. Fox was an advocate for the hollow axles, but he did not consider the present experiments quite conclusive, as there were differences in the relative dimensions of the axles experimented upon; he would suggest another series of trials, upon a larger number of axles, as the subject was one of great importance, not only to manufacturers, but to the public, whose safety in travelling depended upon the goodness of the axles under the carriages. He had used upwards of 5000 axles made by the Patent Axle Company, and had made many experiments by breaking them; the average result was equal to that quoted by Mr. York. He agreed in the danger arising from over-heating iron, as also from over-hammering it, and for some time past he had caused all the axles to be made 6 inches longer than was necessary, in order to cut 3 inches off each end, to try the quality and the appearance of the fracture of the iron.

The President remarked, that there could not exist a doubt as to the greater strength of a hollow axle, as compared with a solid one, both containing the same weight of material; the principal question to be considered was, that of vibration, and its effect upon the cohesive strength of the metal; whether the action upon the particles was more irregular in the solid body, and more distributed in the hollow one; he recommended this investigation to some of the mathematicians who were present; the result of their inquiries might materially aid in the development of truth from the practical experiments.

Description of the Roofs over Buckingham Palace, covered with Lord Stanhope's Composition. By Peter Hogg, Assoc. Inst. C.E.

The mixture invented by Lord Stanhope, and used by the late Mr. Nash, for covering the nearly flat fire-proof roofs of Buckingham Palace, is described in the paper as being composed of Stockholm tar, dried chalk in powder, and sifted sand, in the proportions of three gallons of tar, to two bushels of chalk, and one bushel of sand, the whole being well boiled and mixed together in an iron pot. It is laid on in a fluid state, in two separate coats, each about three-eighths of an inch in thickness, squared slates being imbedded in the upper coat, allowing the mixture to flush up between the joints the whole thickness of the two coats, and the slates being about an inch.

The object in imbedding the slates in the composition, is to prevent its becoming softened by the heat of the sun, and sliding down to the lower part of the roof, an inclination being given of only one and a half inch in ten feet, which is sufficient to carry off the water, when the work is carefully executed. One gutter, or water-course, is made as near to the centre as possible, in order to prevent any tendency to shrink from the walls, and also that the repairs, when required, may be more readily effected. It is stated, that after a fall of snow it is not necessary to throw it from the roof, but merely to open a channel along the water-course, and that no overflowing has ever occurred; whereas, with metal roofs it is necessary to throw off the whole of the snow on the first indication of a thaw.

These roofs have been found to prevent the spreading of fires, and it is stated, that on one occasion, to test their uninflammability, Mr. Nash had a bonfire of tar barrels lighted on the roof of Cowes castle.

Another advantage is stated to be, the facility of repair which the composition offers, as, if a leak occurs, it can be seared and rendered perfectly water-tight, by passing a hot iron over it; and when taken up, the mixture can be remelted and used again.

The author proposes to obviate the disadvantage of the present weight of these roofs, by building single brick walls at given distances, to carry slates, upon which the composition should be laid; instead of filling the

spandrels of the arches with solid materials, as has been hitherto the custom.

The reported failures of this species of covering at Mr. Nash's house in Regent-street, and in other places, are accounted for by the composition having been used in one thin coat, laid upon an improper foundation of laths and tiles.

The durability of the roofs, which were carefully constructed with good materials, has been, it is contended, fully proved at Lord Palmerston's house, which was covered with the composition in 1807, Lord Berwick's, in 1810; Sir James Langham's, in 1812; the Pavilion at Brighton, in 1816 and 1823; and nearly the whole of Buckingham Palace, in 1826 and 1829; the roofs are stated to be in perfect order at the present time, and have scarcely demanded any repairs since their completion.

The paper is illustrated by a drawing, showing the mode of constructing the roofs, and the improved method proposed by the author, with specimens of the composition, with slates imbedded, taken from the roof of the palace during some recent alterations.

Mr. Poynter presented a drawing of the mode of setting the pots for melting and preparing the composition, the proportions of which he stated somewhat differently from those given in the paper.

Three measures of ground chalk, dried and sifted very fine, were mixed and kneaded up with one measure of tar; these ingredients were melted in an iron pot, set in such a manner that the flame should not impinge too violently upon it. The first, or "skimming" coat of the covering being laid on of a thickness of 3-16ths of an inch, the finishing coat was composed by adding to the former mixture three measures of hot sifted sand, well mixing the whole together; the composition was laid on with a tool similar to a plasterer's trowel, but much stronger.

Mr. Nash, when he first tried the composition, found that the surface became disintegrated by exposure to the weather; he therefore added the slates imbedded in the second coat, and subsequently never used the mixture without them.

In reply to questions from the President and other members, Mr. Nixon stated, that he was employed under Mr. Nash when the palace roofs were executed, and he could bear testimony to their durability and soundness. The roofs at East Cowes castle, which were covered with the composition in the year 1808, and those of the Pavilion at Brighton in 1816, were now in as good a state as when they were finished. The failure at Nash's house in Regent Street arose from the roof having been originally composed of mastic, which soon cracked. One coat of the Stanhope composition was spread over it to stop the leaks, but it was insufficiently done, and ultimately Mr. Rainy had a new roof, properly constructed, with two coats of composition, which had remained sound to the present time. The price of these roofs, when well constructed by the person who did those of the palace, was about five guineas per square.

Mr. Hogg observed, that the chalk was only exposed to such a heat as would evaporate any moisture it contained. The weight of the two coats of Stanhope composition, including the slate imbedded in it, was about 12 lbs. per superficial foot.

Mr. Sibley considered the Seyssel asphalte, when carefully laid, preferable to any composition of a similar nature; he had used it extensively, and was well satisfied with it, both for roofing and paving.

Mr. Hogg objected to the use of asphalte for roofing, as it was liable to injury, being of a brittle nature; it was not elastic, and it shrunk from the walls, thereby causing leaks. Lord Stanhope's composition did not possess these faults, and he did not consider that it was superseded by asphalte.

Mr. Moreland had covered the roof of the tread-mill at the Giltspur Street Compter with asphalte, and had found it answer perfectly. It was laid on in a thickness of 3 8ths of an inch, upon roofing boards three-quarter inch thick, with canvass nailed on them; with an entire fall of only nine inches, there was not any appearance of leakage.

Mr. Davison had caused a school room to be floored with asphalte four years ago, and up to the present time there was no symptom of wearing down, although the stones, which were let into the floor for supporting the desks, &c. were considerably abraded. He believed that the only failures of the asphalte had occurred from the use of inferior ingredients. Gas tar had been used instead of vegetable tar, and in those cases the result had not been successful.

Account of the Victoria Bridge, erected across the River Wear, on the line of the Durham Junction Railway. By David Bremner, Assoc. Inst. C.E.

The district through which the Durham Junction Railway passes, for the purpose of completing the connexion between the city of Durham, with the towns of Newcastle, South Shields, and Sunderland, is extensively undermined by coal-workings, and great caution was requisite in the selection of a spot which suited the level of the railway, and where a foundation could be formed sufficiently sound to support such a structure as the bridge described in the paper. The advice of Messrs. Walker and Burges was therefore sought by Mr. Harrison, the engineer of the line, and their design was adopted; but subsequently several alterations were made, either to favour the locality or from motives of economy.

The bridge is 810 feet 9 inches long, and 21 feet wide, between the parapets. It is, with the exception of the quoins of the main arches, built of freestone, from the Pensher quarries; there are semicircular arches, of 144 feet, 100 feet, and 60 feet span respectively, a centre arch of 160 span, with a radius of 72 feet, and three arches of 20 feet span each at either end, forming the abutments. The main pier is founded upon rock, 24 feet beneath the bed of the river; and the height from the foundation to the top of the parapet is 156 feet 6 inches; the under side of the main arch, at the crown, is thus 121 feet 9 inches above the level of the sea.

The paper describes at length the nature of the building materials employed, the dressing of the stones, the composition of the mortar, the general detail and dimensions of the construction, the centering of the arches, with the precautions used in striking them, and gives a very full account of the travelling and other cranes employed in the construction; these are stated to have been very efficient. The north arch, of 100 feet span, containing about 980 tons of stone, was entirely turned with two of the cranes, in 28 hours, giving an average weight of 17½ tons of stone laid by each crane per hour.

The perseverance and practical skill of Messrs. Gibb, of Aberdeen, the contractors, are particularly mentioned, as the difficulties attending the getting down the foundations, especially that of the main pier, were very great, and required all their talent and energy. The detail is given of the precautions taken with the coffer-dam, in which at one period a steam-engine of twenty-horses power, working two pumps of 18 inches diameter each, was insufficient to keep down the water, and it became necessary to drive a range of sheet piling all round withinside the dam, before the leakage through the bad strata above the rock could be stopped.

By calculation, it appears that the pressure on the foundation of the highest pier in the bridge is about 37 tons on each square foot, exclusive of the additional weight of the passing coal-trains, which frequently weigh 120 tons each.

The bridge was commenced on the 17th of March, 1836, and was finished on the 28th of June, 1838, occupying about 714 working days, and cost, with the extra works, nearly £40,000.

The paper is illustrated by three drawings, showing a plan and elevation of the bridge in several stages of its construction, and when completed; the details of the centres, hoists, and cranes, the coffer-dam, engine, pumps, and of the foundations of the whole structure.

The President observed, that the structure first proposed was to have been of cast-iron, but when he and his partner, Mr. Burges, were consulted, they advised the employment of the freestone from the adjoining quarries, on Lord Londonderry's estate, and they furnished a design, based upon that of Trajan's bridge, at Alcantara, which was adopted by the directors; but subsequently an alteration was made, by introducing three small arches in each abutment, which, in his opinion, had injured the design; that was the extent of his connexion with the bridge; the merit of the construction must be given to the engineer and the contractors, and he must corroborate the statement of the superior manner in which the work had been executed. The bridge had been placed nearly at the spot marked out by Mr. Telford, for the Great North Road to cross the Wear, and as the railway would now form part of the line between Newcastle and Darlington, Mr. Telford's plan would be virtually executed, although with the difference of substituting a railway for a turnpike-road.

MISCELLANEOUS.

PARHELIA.

East Retford, June 16, 1843.—We have this day had an opportunity of witnessing one of the most interesting atmospherical spectacles it was ever our good fortune to behold—that of a splendid corona, which ultimately ended in exhibiting two parhelia, or mock suns, which being so unusual a phenomenon in these latitudes, we will attempt a brief description of both, as well as the shortness of our actual observations, and our consequent want of the necessary preparations, will conveniently allow us. During the early part of the morning the atmosphere generally was of a somewhat densish character, with the wind due east, and having every appearance of producing a subsequent hot day. The thermometer during the morning had ranged from 54 deg. to 58 deg., and the barometer manifested a disposition to rise, although it had been stationary several hours. About 11 A.M. a thick scud appeared to be collecting

in various parts of the heavens, and the wind shifted from E. to E.N.E., the sun at the same time becoming partially obscured, which induced many persons to infer that a thunder shower was approaching. At twenty minutes past 11 the density of the atmosphere had evidently increased, and the midheavens appeared to be a conglomeration of the nimbus, or rain cloud, which tended materially to strengthen the opinion that a storm of no very ordinary magnitude was approaching. At this juncture the face of nature had a very singular and imposing appearance, owing to the reflection of the slate-coloured clouds in the midheavens casting their gloomy shadows on the surface of the earth, far as the eye could reach, causing many to apprehend that some convulsion of nature was at had, or otherwise that some atmospheric change was in operation, unusual in its appearance, and apparently mysterious in the effects which it might ultimately produce upon terrestrial objects and matters pertaining thereto. About this period too, the feathered tribe were struck mute with astonishment, and seemingly impressed with an instinctive dread of consequences; even the shrill chirp of the soaring swallow was scarcely heard amid the gloominess which everywhere extensively prevailed. Nor was this instinctive kind of fear confined to them; numbers of our townspeople seemed to apprehend either that a storm of fearful import was impending directly over the place, or otherwise that some convulsion of nature was in store for them; and many anxious inquiries were made in every direction as to what might ultimately be apprehended. At length it became sufficiently apparent to those conversant with atmospherical phenomena, that either a corona or a parhelion, or both, were about to be witnessed, and we made such preparations for observing them as the shortness of the notice and the extraordinary nature of the circumstances would allow.

Exactly as the sun reached the meridian, the circular cloud, which was about 40 degrees in diameter, appeared to be perfected, at which time its outer edge was encircled by a broad whitish ring, which gradually became more and more burnished until it had assumed a brightness, in a great measure, equal to the sun itself, so that it was almost impossible for the human eye to look at it for any length of time. Remaining in this state for more than forty minutes, this circle gradually developed itself towards the east and west, forming a kind of ellipse, of which not an unfitting representation may be found in the letter O, which gave to the sun an appearance of being surrounded by a complete rainbow. The broad parts to the east and west were somewhat more deficient in colour than were the narrow portions to the north and south, which being confined within narrower limits exhibited all the most brilliant colours of the Iris; the inside being red, and the rest following in regular prismatic order. Shortly after 1 P.M. five other concentric rings were discovered; the arc of the first being parallel to the horizon, passing directly across the sun's disc, proceeding northwards, and from this two other circles diverged east and west. These rings were of a whitish cast about 30′ broad. Within the arc of one of these last-mentioned circles were observed two others crossing each other at right angles; both of these, however, were faint, and gradually disappeared within less than 20 minutes. We were now left with three circles, the two surrounding the body of the sun, and circumscribing the dense mass of vapour, and the one we have described as extending about 90 degrees northward, and passing directly across the sun's disc. As the sun progressed westward, this last mentioned circle changed its position from N. to N.E., and at a little after two o'clock the phenomena might, properly speaking, be said to have changed from corona to parhelia; for at half past two were distinctly seen on the same circle two mock suns, the one directly north, and the other due east of the sun's centre: that to the north was surrounded by the iris, and well defined—the other more indistinct and of a faint reddish colour. At this period likewise the sectional parts of two circles, coloured like the iris, were seen—one in the N.W. subtending an arc of 60 degrees, the other in the S.E. having an arc of 16 degrees. At about three o'clock the whole scene gradually became fainter and fainter, and finally disappeared in thin haze; the sun breaking forth in the fulness of his majesty, and the heavens once more resuming their wonted serenity. We would here observe that the only modification of cloud to be observed both previous to, and during the progress of the phenomenon, and subsequent thereto, was that of the cirrostratus or wane cloud, which had a most beautiful and picturesque effect—forming what is usually designated "Noah's Ark;" and being directly in the wind, had the very appearance of the bottom of a ship, beautifully curved to the east and west. This, taken in conjunction with the other appearances above described, had a most singular and imposing effect—so much so indeed that we heard a neighbour gravely exclaim, that the whole heavens were then so beautiful that he should like to have a picture of them, feeling convinced that the *tout ensemble* would form a most splendid *landscape!*

Having given a faint, and we fear, very imperfect description of this scene, we will now briefly proceed to notice the causes which are supposed to give rise thereto, as well as the effects which may be expected to arise therefrom. It is said that when parhelia occur, the weather is never serene, but this was not the fact on this occasion. They only happen, according to Sir Richard Phillips, in misty, cold weather, and therefore mostly occur in the polar regions, as Greenland, Hudson's Bay, &c., or in marshy countries, like Holland; because they rise only from the light of the celestial bodies reflected by the haze or mist. The aqueous globules disseminated through the air, are said to be congealed within, and liquid without. The dense part intercepting the rays, affords the requisite shade, while the liquid parts transmit those same rays, then coloured by the double refraction. The diversity of aspect depends upon the volume of the globules, on their position, quantity, and state of congelation; and, however numerous they appear, only the same one is multiplied by a series of refractions and reflections. Now this description is not only suitable, but quite answerable to the weather we have been experiencing for the last six weeks. The month of May has been the coldest and the wettest we have had to contend with for many years past; in consequence of which the surface of the earth having become so completely saturated, the natural exhalations were prevented being carried into effect by the cold which prevailed; and the general low state of the temperature, by night and by day, not assisting such exhalations, but rather tending to prevent them, would cause an immense quantity of watery globules to be stationary within the limits of the earth's atmosphere, and waiting the arrival of a higher temperature for its dispersion. This was particularly foreboded by the somewhat extraordinary rise which took place in the mercurial column within twenty-four hours of the corona becoming visible. For several days previous thereto, the barometer had been nearly stationary at about 29·10 inches; whereas, within a very short period of its approach it had reached 30·06 inches, at which point it remained for two or three days. The sun, too, having nearly attained to his greatest north declination, and consequently being in the zenith of his might, would tend materially to assist the exhalations then in progress, and draw into a focus the watery globules, which formed the dense and circumfluent mass immediately surrounding the body of that luminary, and which, by being refracted and reflected throughout the heavens was the cause of the grand display we have just been attempting to describe.

When parhelia disappear, as has been remarked, both on the continents of Europe and America, it sometimes rains, or, perhaps, a fall of snow succeeds; the flakes of which are in the form of oblong spiculæ, as Miraldi, Weidler, Krafft, and others have observed; and because the air in North America abounds with such frozen spiculæ, even visible, according to Ellis and Middleton (two of the best American writers of atmospherical phenomena), such particles have been thought to be the cause of all coronas and parhelia. In our variable climate, and when upon the summer solstice, this can scarcely, perhaps, be said to apply to England; nevertheless, these phenomena cannot even happen here without much cold, and, in our judgment, these were rendered a matter of necessity on the present occasion towards taking away and dispersing the cold we have latterly been experiencing, and in restoring to us the blessings and immunities which the genial rays of a summer's sun can alone bestow upon the industry of man, in bringing to perfection the various products of the fruitful earth. Since Friday last, the air has been sharp from the north and east, especially during the nights, and even in the day time in the shade, yet such has been the powerful influence of the solar rays, that the weather may be deemed to have been all that could be reasonably desired; and we see no cause for revoking the opinions we have propounded in a previous article, that the present summer will be dry and warm, and the autumnal season highly productive. On the contrary, we think we can perceive, in the late extraordinary effort of nature to rid the atmosphere of an extreme and unusual accumulation of aqueous and cold vapours, by the most powerful means which she can adopt, a foretaste of such desirable weather, by a combination of such causes as must ultimately ensure it.

Parhelias have been mentioned both by ancient and modern writers, but they very rarely occur in England, and even then they may only be seen by a comparatively small portion of the inhabitants. This may appear somewhat extraordinary; but as a proof of the correctness of the assertion, we may mention that several parhelia were observed at Haerlem, in Germany, on the 22d of February 1734, and were not noticed at Utrecht, although only thirty miles apart. Aristotle supposed that these appearances were seen only when the sun was near the horizon, and yet, strange to say, he notices two seen in the Bosphorus, which lasted two whole days. Gassendi, the justly celebrated French philosopher, in 1635 and 1636, frequently saw one mock-sun. Two were observed by De la Hire in 1689; and by Cas-

sini in 1693; Grey in 1700, and by our Dr. Halley in 1702; as well as two at Lyndon, in the county of Rutland, on the 22d October 1721, at eleven in the morning. But the most celebrated appearances were seen at Rome by Scheiner; by Peter Muschenbroeck, at Utrecht; and by Hevelius, at Sedan. By the two former four mock-suns were observed, and by the latter seven. It is recorded that four red ones were seen on the 8th April 1233, in Herefordshire and Worcestershire; which were succeeded by an exceeding warm summer, and one of the coldest winters ever then known. Five mock-suns were seen at Rome, March 29th, 1629; and three at Salones, in Provence, April 16th, 1783. We believe there are a few others on record, but they are very few, and none of them in any way approaching in sublimity and grandeur to the one we were favoured with witnessing on Friday last. Since that day we find various vague and conflicting rumours afloat, as to the effect it is likely to produce in mundane affairs; others that a wet summer may be expected; and for the verification of this latter position we find the year 1816 quoted, as having witnessed a similar exhibition, and a very wet harvest. On looking over the annals of that remarkable year, however, we cannot find any circumstance of that kind as having taken place in any part of England. The wet harvest was by many persons attributed to certain large spots which were then traversing the sun's disc; but these are of a nature so different and distinct from parhelia, that we cannot for a moment mistake the one for the other; or attribute effects to the one which it is barely possible the other may or may not produce.

J. S. P.

Bothway's Iron Blocks.—An experiment has been made in Plymouth dock-yard to try the comparative strength of Mr. Bothway's single metal blocks against the rope it is calculated to take, viz. a 3-inch one. A rope of that size was rove in the block, and one end brought to a windlass, and hove on until it broke. A 3½ inch was then tried; though larger than required for such a block, this also gave way; and the last is considered by practical men fully equal to the powers of an 8 or 9 inch block. The iron blocks have also another great recommendation in doing away with the rope strappings, as many serious accidents have occurred by their breaking.—*Mechanics' Magazine.*

Plymouth Breakwater Lighthouse.—This important addition to the national works in Plymouth harbour is near completion; the third story of the building, and the room for the keeper, with the oil and store-rooms, are already finished—the fourth room will be the sleeping apartment; the whole of which is dry set at the breakwater quarries at Oreston, where persons, who are desirous of ascertaining the nature of works of this description, may be gratified by an inspection.

Channel Harbours.—The importance of securing to the innumerable shipping that navigate our Channel, harbours for refuge during the squalls and gales to which our coast is periodically subject, has become so apparent, that, independently of that assistance which might be expected from the government, in an undertaking as national as it is local and mercantile, it is understood that in some points of the Channel, harbours of this kind are already being or about to be formed. The small port of Folkestone, near Dover, will be one of the first to be so provided. This harbour is in bad weather the rendezvous of a very considerable number of small coasters and fishing smacks, but although comparatively secure, they ride very heavily, and often meet with adversities from the chopping of the wind. A floating breakwater, however, in an eligible position, near Folkestone, is now constructing, which will render it perfectly secure in all weathers from the action of winds and waves. This breakwater, or buoyant sheltering sea barrier, is the invention of Captain Adderley W. Sleigh, a gentleman who has for many years devoted his attention to the formation of harbours of refuge. It is simple in construction, and comparatively inexpensive, and is suggested by the natural opposition which the strand offers to the encroachment of the sea; in fact, it may be termed an artificial beach. The apparatus, now constructing at Ponton Dockyard, Nine Elms, Battersea (which will be ready for launching in a few days), is on a small scale; it consists of three barriers of 85 feet each in length; it will be moored in the shape of a crescent, and is calculated to afford shelter to an anchorage of 2000 square feet. One of the results of this experiment will doubtless be the great advantage and importance it will give to Folkestone.

Gigantic Fossil.—A fine specimen of the Plesiosaurus Macrocephalus, has recently been found in the lias formations at Barrow-upon-Soar. It measures fourteen feet in length, and is the only one of the kind that has been found in the neighbourhood. This species is by no means common, and is as singular as it is rare—the neck of the animal appears to be nearly as long as the body, while that of the Ichthyosaurus is just the reverse, having a short neck and very long tail.

Channel Lights.—As the town of Folkstone is now lighted by gas, it has been deemed proper to place a red light on the West Pier Head, instead of the former white light. Cape Grinez light is now a revolving light, showing every half minute, to the extent of eight leagues, with a continued fainter light visible four leagues; the flashing light and the fixed light at that place are discontinued. The light at Calais shows at lapses of 1½ minutes—the intervals are totally dark.—*Hampshire Telegraph.*

New Method of making Type.—A patent is about to be taken out for producing printing types on a new principle, without the necessity of casting. The amalgam of the metal will be different to that now used, being harder, consequently more lasting, and better adapted for machine-printing. The cost, it is expected, will be rather lower than at present; but the principal economy will be in its durability. With the aid of the electrotyping process, some ingenious practical men in London are realising money by supplying small founts, and what are technically termed lines, sorts and fac-similes, at very reduced prices.

Proposed Iron Harbour of Refuge on the Goodwin Sands.—Mr. Bush has submitted plans to the Shipwreck Committee of the House of Commons, for the construction of an enormous harbour, by means of caissons upon these sands; and which he proposes should either be undertaken by the government, or by a company of private individuals. The whole plan embraces an embankment by the means of caissons and concrete, of rather more than 11 miles in extent. Upwards of 800,000 tons of iron would be used, which at £5 per ton, would cost £4,000,000. It would take, according to Mr. Bush's calculation, 11 years to construct, and 7000 men would have to be employed during that period, at 15s. per week; giving a round sum of £3,003,000. Each caisson, according to the scale submitted to the Committee, would be 100 feet long, 54 feet high, 36 feet at the base, and would diminish one foot in six. It would contain 172,800 cubic feet, and weigh 1300 tons, and being floated off to its destination, would be filled with concrete, and would then weigh 13,000 tons. The plan upon paper appears stupendous,—what would it be to carry into effect, amid the fierce contention of the wind and waves, and the constant shifting of the sand!

The Boccius Light.—At the Society of Arts, on Wednesday, June 14, Dr. Atkin read an interesting paper, descriptive of this new light. The lecture-room was lighted by one burner in the centre, sixteen feet from the floor, which diffused a mellow light into every corner of the apartment, showing to the greatest advantage the beautiful paintings which adorn the walls; two small burners, one inch in diameter, were also at the chairman's desk. The paper entered into a very full historical notice of the investigations into the theories of artificial lighting which have taken place during the last thirty years, from the first discovery of the Bude light by Mr Goldsworthy Gurney, in 1814, up to the present time; it gave a very lucid explanation of the *rationale* of the combustion of the various hydro-carbons as applied to artificial illumination, and explained the extraordinary powers of a stream of oxygen and hydrogen, when mixed in the proportions to form water, commonly known as the hydro-oxygen blow-pipe, and which when ignited, though only a dull light is produced, gives out the most intense heat known, before which every known substance in Nature melts (charcoal excepted) and the diamond is consumed, producing, with the oxygen, carbonic acid. It described the immense advantages peculiar to the Boccius light, which are—the greatest possible amount of light, with the least possible consumption of gas—a perfect combustion of the carburetted hydrogen, and consequently, no deposit of soot over the apartment—complete ventilation—and last, though not least, a saving of from 25 to 60 or 70 per cent., according to the size of the burner, as, the larger it is, the greater the saving effected. As a proof of the correctness of these calculations, the reports were read of Professor Brande and Dr Atkin, who had carefully tested the qualities of the Boccius burner; to be perfectly correct, they employed a nicely-graduated Defries' patent dry gas meter, measuring the gas by it; and determining the superior intensity of the light by Professor Wheatstone's photometer. These gentlemen gave as their opinion, that the Boccius light is superior to any that had been yet introduced, taking into account the illuminating power, the pure state of the atmosphere in apartments where they were used, and the extraordinary saving in the gas consumed.—*Mining Journal.*

ARCHITECTURAL EDUCATION.

Education is little understood in this country, and especially professional education. A few years since, the routine of tuition, falsely so called, in almost all our schools, consisted in fully explaining to the scholars that they must either learn by rote the tasks that were senselessly and arbitrarily selected, or submit to the penalty of idleness, or a want of verbal memory—an indecent and cruel punishment. This was all that the masters taught. This mode of conducting schools, —for a system of tuition it cannot be called, produced either learned fags or ignorant pretenders: the judgment was uncultivated, the imagination was checked, and free independent thought entirely destroyed. The greater number of men who, after passing through the mental exercise to avoid the bodily suffering, in any degree distinguished themselves, were the mere slaves of precedent, and rarely possessed any higher faculty than that of ingenuity. For this reason the men of genius who could shake off the prejudices of education, and be what more generous nature made them, displayed the grace, symmetry, or manly energy of their minds in all the gorgeous lights which the knowledge of ancient mythology and poetry threw around them. The few men who in that age distinguished themselves, were those who, by an innate power of masculine thought, and an imagination that spurns bondage, were able to cure all the diseases implanted by education, and to nurture the independence and royalty of their own natures. The masses of the people were then avaricious and purse-proud, and the intermediate classes consisted of fops, pedants, and schoolmen.

From this system but little wholesome fruit was gathered by the people, and they were the first to suggest that the tree itself might be improved by grafting and culture. The first plant grafted upon this crab-bearing trunk, rendered it more generous and fruitful, but still the produce was without quality and flavour. Each new graft presented a brighter blossom, and yielded a finer fruit, but it did not possess the virtue of infusing health and activity into the nature of him who partook of it. A better system of grafting has now been acquired, and more fruitful plants have been obtained, but all has not yet been done that is required. In fact, it has now become the custom to teach in our schools, but the mode of teaching is defective, and that which is taught has so little active influence upon the mind, that much which is attributed to education belongs to the mind brought under its influence. There was a time when the intellectual growth was stunted by feeding the mind with a knowledge of words instead of things; that time has passed, and it now only remains to exercise a sound judgment of the quality of knowledge to be imparted, and the mode of presenting it to the mind.

But although great improvements have been introduced in the general system of education in our own day, it may be doubted whether professional education has made a single advance in the same direction. The solicitor's articled clerk is still alternately a lackey at public offices and judge's chambers, and a thoughtless copyist of legal forms. From the time he enters his profession to the time he is admitted to practice, he has no exercise for any of the higher faculties of mind, and if he has any education, it is only in cunning and the meanest trickery. The architectural student commences and closes his vocation in the office as a copyist. He has, it is true, fewer temptations to vice than the youth who is placed in the attorney's office; there is nothing necessarily demoralizing in his pursuits, but much calculated to excite and cultivate the imagination, although the other faculties of the mind are left unimproved. The student of medicine is the only professional man who is really educated, or who is indebted for more than mechanical skill to those who profess to be his teachers. But without dwelling any longer upon general statements, we will endeavour to describe the mode in which the architectural student is prepared for the practice of his profession, and then point out some of the most evident deficiencies in the present system of architectural education.

When a youth enters the office of an architect, it is, and the phrase is universally adopted, "to learn his profession," not to be taught. This is the foundation of the system of which there is so much reason to complain. A plan or a simple elevation is placed before him to copy. The use of instruments he acquires from seeing them employed by others, and the facility of drawing from practice. The names of the different parts of a building he picks up from conversation with others, and the professional phraseology from copying specifications. If the youth has any "taste for drawing," he at last becomes useful, and is able to render more or less assistance to his employer, who is fully satisfied with his knowledge of his profession, while the youth, with all the confidence of ignorance, enters the world with bright hopes of success, but with no well-grounded prospect.

That this is the whole amount of information usually obtained in an architect's office, no one will doubt, and yet, if the student has learned no more, he has all his professional knowledge to acquire. A capability of making a good drawing, is that to an architectural student which the ability to write is to a man who would be an author. So far from being the end of his studies, it is but the means of commencing them. Drawing and writing are descriptive arts, and their only use is that of communicating ideas to others without speech. In one the image or resemblance of the thing is presented to the mind, in the other the symbols by which it is represented. They are alike means to an end, and a man who is nothing more than a good architectural draftsman, has no claim to a much higher rank of acquirement than a superior writing master. To judge of an architect, therefore, by his style of drawing, would be as absurd as to fix the qualifications of an author by his hand-writing.

It is extremely difficult to frame a definition of architecture to include all that it comprises. But it has been properly divided into two parts,—Architecture as a science, and Architecture as an art. Either of these subjects may be known without an acquaintance with the other; a thorough knowledge of both is too rare among the practitioners of our day, although they are both required to make the art of architectural drawing as useful as it ought to be to its possessor.

Architecture as an Art comprises an acquaintance with all the styles adopted by nations in the successive eras of their history, and the buildings in which those styles have been employed with the greatest judgment and taste. To trace the connection between those styles and the habits and opinions of the people who invented or modified them, requires a stronger effort of mind, but it is one to which the thought of the student should be directed. In comparing the several styles, and forming a judgment upon their claims to the attention, either in their properties, details, or ensemble, the student will be insensibly brought to inquire what are the elements of beauty or grandeur, and it will be well if in this investigation, unassisted by a mentor, he escape the snares and pit-falls of the metaphysicians and schoolmen. These are but a few of the subjects which should be embraced in an architectural education, but they are all neglected. To distinguish between Grecian and Gothic; to name the styles of the one and the periods of the other; and perhaps to be familiar with some of the leading features of each, the student is ready to believe must be all that is required for successful practice; and should, under any peculiar circumstances, details be required, they may be copied from books,

or at the worst be so designed as not to be very unlike what they ought to be. That a profound knowledge of the history, literature, religious systems, domestic economy, arts and manufactures of the people whose architectural styles he adopts, is necessary, never for a moment finds a place in his mind. Yet an architect properly instructed should possess all this, in addition to a knowledge of the subjects before mentioned.

Architecture as a science is, if possible, still less known to the pupil, when he first leaves the office of his teacher, than the art. The names of the materials used in building he may be familiar with, from having heard them frequently mentioned, but he knows nothing of their composition, nor of the sources of decay to which they are subject; nothing of the reason why they are suited for use in one situation, and unsuited for another; nothing of how or where obtained, the processes by which they are prepared for the builder, nor of the manner in which he applies them to his purpose. The word " truss" he has often heard, and drawings he must have often seen, but of the principles upon which it is formed he is utterly ignorant. If required to prepare a drawing of a roof, he would follow without deviation some plan that he had before seen, and to design for any peculiarity he would feel himself utterly incapable. With all this ignorance of matters which a few months' instruction would fully explain, it is not to be supposed that he can possess any sound scientific information. A good architect should be thoroughly acquainted with all the experimental and mixed sciences. The principles of statics and dynamics are the principles of construction. Mechanics he will require to guide him in the application of machinery in the progress of his works. Pneumatics and the science of heat in adopting proper arrangements for warming and ventilating. Chemistry is always useful, always wanted : in fact, an architect must be a man of science as well as an rtist.

Let it not be supposed from what has been stated that there is any desire to disparage the qualifications of the young men in the profession. Our object has been to show the natural consequence of the present system of architectural education. That many men of great promise are rising in the profession, is but an additional argument for an improved system of education. If with such limited opportunities of acquiring knowledge any of the students of architecture have the energy, perseverance, and ability to distinguish themselves in their profession, it may be anticipated that some display of genius and taste equal to the requirements of the age would be the result if their opportunities of being taught were even proportionate to their determination to learn. A large number of architectural students belong to the class we have described, and it is only the man who has a mind of masculine proportion and energy who can, in the present destitution of means of instruction, form a correct estimate of what an architect should be, and place a high ideal standard of excellence before him for imitation.

The establishment of two professorships of architecture in the metropolis, in the collegiate establishments, encourages the hope that some great improvements will be made in architectural education at no very distant period. The acknowledged acquirements, taste, and energy of the gentlemen who fill those chairs are sufficient guarantees for the full accomplishment of the objects of those establishments. They have perhaps done wisely, for the present at least, in confining their attention to the delivery of lectures, with such examinations as are founded upon them. This is not, however, all that may be hoped for. Subjects for competition designs should be occasionally proposed to the pupils, which should be decided in reference to arrangement, architectural elevation, drawing, or colouring, or from a consideration of the relative merits in all these particulars combined. In addition to these competitions in design, it would be advisable to propose frequently subjects for essays connected with the art or science of architecture, directing the student at the same time to the best native and continental works on the several subjects. This would be attended with many advantages; it would have a tendency to cultivate a good style of composition, induce the habit of study, supply a valuable fund o information, and establish an acquaintance with the best professional writers. There are two difficulties in the way of the adoption of these suggestions—the indolence and lethargy of students, and the inadequate remuneration of professors. If we know any thing of the zeal and self-denial of the man of true learning, the latter would not long be an impediment if the other could be removed. But this can and will be corrected by time, and in all educational plans, the arrangements must be made for the industrious and not for the idle.

The French school of Fine Arts has adopted the system of competition designs among the pupils with no unequivocal success. Dark indeed must be the misanthropy of that man who would rob his own nation to crown another with honour, and we shall not be suspected of depreciating the acquirements of the architects of England to extol those of the architects of France; indeed, we cannot admit that they have more fancy or imagination, or that they are distinguished by a superiority in judgment and practical skill, but as a class they are certainly better informed. To a profound knowledge of ancient art they have added a sound acquaintance with the history and antiquities of their own country; and they also possess a wider range of theoretical knowledge. The soundness of their professional education is the cause of this superiority. But this education in youth induces study in maturity, causes the union of minds with similar pursuits, for mutual improvement, and provides a stimulus to the attainment of honourable pre-eminence.

As an example of the manner in which the subjects for designs are proposed in the French schools, we will give an example of one recently competed for in the Academy.

"SUBJECT—A PALACE FOR THE ARCHIVES OF THE KINGDOM.

" This edifice, destined for the reception of the Records and Acts of State, should comprehend, on the ground and principal floors, five distinct departments, viz. the archives of administration, the historical archives, the archives relating to landed property, the judicial archives, and the archives of the civil service.

The four first departments will each occupy nearly the same space; and will be divided into three sections, comprehending the necessary galleries and saloons for the proper classification of the documents.

The archives of the civil service being more numerous, will require a much greater number of sections, among which, those of births, marriages, and deaths, are most important.

Attached to each of these five departments will be large rooms for classification, and small offices for the work necessary to be performed, together with the necessary vestibules and staircases.

A grand saloon will also form part of the plan, in which will be kept all the more important and precious documents.

This saloon, which will be considered as that of the records of the nation, will be adorned with statues of the kings of France, as well as with sculpture and paintings, representing the memorable historical events, such as legislative assemblies, treaties, &c. It will be approached by an antechamber and a vestibule, in which will be deposited the papers necessary for the registration of the titles and documents which will be deposited in the archives.

Outside the principal edifice, will be a building for the private

residence of the officers of the establishment, and for public offices. This building only will be open to the public, for reference to such documents as are allowed to be shown. It will communicate by galleries with the principal edifice, and contain an office for every department of the archives.

The edifice will be isolated, and surrounded by a wall. A multiplicity of parts in the design, especially in the ground-floor, must be avoided. The arrangement must be simple, and the whole building must be perfectly fire-proof.

In adopting the style of architecture which may be thought the most suitable for impressing upon the building at once the attributes of solidity, safety, and grandeur, unity must govern the design, so that the mass may have an imposing effect.

The site allotted will not exceed 300 metres in its greatest dimensions."

The necessity of an immediate attention to architectural education is forced upon us by the peculiar dangers to which the profession is exposed at the present time in this country. The decorators on the one side, and the Church Architectural Societies on the other, are laying siege to its strongholds, and without some more adequate means of resistance than it now possesses, they will assume control over some portions of its territory. The decorator, one who pretends o the skill of an artist for the purposes of trade, relieves the architect, if he be so inclined, from all necessity for thought in the internal finishing of the houses he erects, and at the same time reduces him to the rank of a foreman of bricklayers and carpenters. We do not say that professional men in London are in the habit of delegating the duties, and important ones too, they have to perform in the internal finishings of dwelling houses, to painters and paper-hangers, for such these decorators were formerly called, but instances have come to our knowledge, whether from the ignorance or idleness of the architect, we are unable to say. One thing, however, is certain, that they assume the duties of the architect when occasions arise, and in many respects tend to lessen the honour in which the profession was formerly held. It is to the advantage of the employer as well as the employed that there should be order, and we doubt much whether a tradesman would attempt to interfere with the duties of the professional man, if he were conscious of that man's superiority in knowledge as well as his right to command. But of one thing we are certain, that the conscientious tradesman never undertakes an engagement so willingly, or performs it with so little trouble or so much satisfaction, as when directed by a qualified architect.

The influence of the church architectural societies, as now conducted, is most prejudicial to the profession, for their object is to establish a higher authority in architecture than the profession itself. The principles upon which they are formed are false, for they assume that a mode or style is incapable of improvement, and that none other can be brought into comparison with it. But this is a subject upon which we have not now either time or opportunity to enlarge.

The necessity for a great improvement in the present system of architectural education, is too evident to require more than the mere statement of the fact. There was a period when the professors of this beautiful and useful art held an enviable rank among the learned, but it was when they had a higher standard of excellence than is now commonly presented to our students. If those days are to be revived, if the art is to advance in our native country, and the public is to be made conscious of the benefits it can confer upon a people, we must improve the system of architectural education.

THE CHURCH AND ENVIRONS OF SAINT NECTAIRE. (DEPARTMENT OF REY-DE-DOME.)

BY ABBE CROIZET.

Nectere, or Nectaire (Necterius or Nectarius), was one of those fathers who came from Rome about the middle of the third century, and accompanied Saint Austremoine (Stremonius), the first bishop of Auvergne. Nectaire finished his course in the ancient Gaulish location Cornadore, which is but a short distance from Mont Dores. He was there buried, honoured by a special sepulture, and the name of Cornadore was changed to that of Saint Nectaire. The illustrious family of that name caused to be erected to the honour of the saint a magnificent Roman church, which exists to the present day, and a monastery of Benedictines, behind the southern side of the church, but now destroyed. In the vestry are preserved some ancient titles on parchment, some of which belong to the third and fourth centuries; also some shrines, one of which contains the heart of Saint Nectaire, another an arm of silver containing his arm, others less ancient in the form of shrines, and others in enamels. In this church there is a bust in oak, worm-eaten, surrounded by a plate of copper formerly gilt, with jewels. The head of this bust, of which the eyes are enamel, is without doubt Romano-Byzantine. It is the bust of Saint Baudime, who, like Saint Auditeur, was a disciple of Saint Nectaire. Some remains of their tombs, as well as of their mortal remains, are yet visible in the church and in the shrines.

The principal altar, which is in the ogival style, belongs to the fifteenth century, as is proved by an inscription on stone, from which we learn that the body of St. Nectaire was raised from the tomb by the prior and St. Anthony de Nectaire. I was informed that there was a large crypt in the granite under this altar; I accordingly caused a large flag-stone to be raised, but could not discover it. Probably the report referred only to a small tomb containing the body of the patron saint. I remarked in the church and in the adjoining cemetery some gravestones, on one of which were the armorial bearings of the house of St. Nectaire. To this house also we owe the beautiful Gothic cross at the northern end of the town, a Latin inscription upon which informs us that it was erected in honour of the corporation.

But the most important religious monument of this commune, is, without contradiction, its fine Roman church, which is at the south end of the town, built upon a granite rock. This church overlooks a lofty precipice, and, since the destruction of the monastery and the castle of the Seigneur, has stood quite alone, free from other buildings.

The porch, the naves, the transept, the choir, and the side chapels, in one word, the ensemble and all the parts of this edifice, are on the same plan as our finest Roman churches, that of Issoire, Orcival, and Clermont (Notre Dame du Port.)

The exterior ornaments, such as the cornices, the brackets, the plinths, and the mosaics, are more simple at St. Nectaire, and thus in more unison with the severe climate of our mountains, but the interior decoration of this monument is very remarkable. I am not afraid to say, that none of our churches has a greater claim in this respect upon the attention of archæologists.

The church is built of trachyte, produced by one of the most ancient volcanoes of Mount Dore, which has passed through the primitive rocks, and following immediately after the super-carboniferous and fresh-water formations at present known by the name of tertiary. The interior contains a hundred columns with capitals, the sculpture in relief of which is worthy of occupying our attention for an instant. These

sculptures comprise flat leaves, interlacements, curled leaves, flowers, grotesque heads, birds and other animals in the middle of foliage, with whimsical subjects, some of which appear to be a criticism upon certain vices, and above all a great number of scenes drawn from the Old and New Testament. We might dilate upon the proportions and costumes of these personages, upon the clouds which encircle the head of our Saviour and his Apostles, the cross which the first holds in his hand, the mantle, and upon the longer and more flowing drapery of our Lord and his Apostles than of inferior individuals; we might point out what persons are depicted with beards and what without; who are barefooted and who not; we might go over the costumes of the females, the coats of mail, the lances, shields, and soldiers, as well as the form of the good and evil spirits. But all this description would not carry us far, and would be much better understood by drawings than by mere description. We shall only pause awhile upon the most characteristic points, although the personages in general are grotesque, and devoid of natural proportions.

Besides the leaves, the flowers, and the birds, which conduce so much to the decoration of the porch, the naves, the transept, and the space round the choir, we perceive, first, Moses saved from the Nile by Pharaoh's daughter, just as he is about to be devoured by a crocodile, which is represented with open mouth before the cradle, and attacked by dogs; second, The demon precipitated into flames, and an angel worshipping the Lord; third, The combat of the good and bad angels,—the good angels are represented armed with shields and lances, the bad in the human form conjoined with that of a serpent; fourth, The triumph of religion or of truth over error, represented by an individual with a head under his feet, and by two others at his side, one bearing arrows, and the other shooting them from a bow; fifth, A quadruped playing upon the harp, and another carrying a young man with a leafy branch upon his left shoulder; sixth, The punishment of the damned, portrayed by the figure of a man whom winged demons are enchaining with serpents; seventh, Two persons naked all but a girdle of leaves, and whose legs terminate in leaves or flowers, —from the midst of these flowers issues a head, with grapes and other fruit in its mouth; eighth, The good shepherd, represented twice upon the same capital, with the lost sheep upon his shoulders; ninth, A grotesque head, and some birds whose tails end in elegant foliage; tenth, A man dragging along another by means of a cord round his neck; eleventh, Zaccheus mounted in a sycamore tree, and our Saviour, accompanied by a crowd of persons, stretching his right hand to Zaccheus and holding a cross in his left; twelfth, Naked figures mounted upon lions, symbols of the force of Christianity and its combats; thirteenth, Other figures lying upon the belly and holding shields in the hands; fourteenth, Falcons with folded wings in the midst of foliage, whilst in other parts are seen other kinds of birds with their wings unfolded.

But it is particularly the capitals of the columns which form the sanctuary and encircle the principal altar which excite the most interest, by reason of the subjects from the New Testament which are sculptured upon all their faces. The capital of the first column, to the left of the spectator placed facing the altar, presents, first, The scene where our Saviour is seized in the night by armed men, with others carrying torches, and that where Saint Peter cuts off the ear of Malchas; second, Christ bound to a pillar: third, The Saviour carrying his cross; and fourth, Showing his side to St. Thomas. On the capital of the next column we see the miracle of the loaves and fishes. The Saviour and his Apostles hold in their hand a round loaf, upon which is engraven a cross; upon two other orders of this capital is depicted the Transfiguration. Our Lord, still holding a cross in the left hand, is placed upon the angle; at the sides are the apostles, Moses, Elias, and two small tents; there is a third and larger tent near Christ; there are also phylacteries, with an inscription in Roman characters. The tents have very inclined roofs, with windows in the centre; but at the top of the gable ends are circular openings. Finally, upon the fourth side of this capital is represented an angel holding a sword in his right hand, and in his left a man in the act of holding on strongly to a pillar, while another individual is grasping the man by his hair, and endeavouring to tear him from his hold. Perhaps by this is meant the column of truth, so often alluded to in Scripture.

The capital of the third column represents our Saviour extending a wand in form of a cross towards an arched tomb, in which is Lazarus rising from the dead; on one side is a church placed in a vessel. This church, with its octagonal tower and other characters, is not unlike the one which contains it. We see also in this capital a little bark protected by an angel, and towards which the Saviour is conducting his elect.

On the fourth capital, is a representation of the angel of destruction, armed with darts, and mounted on a horse—a symbol of the end of the world; also great numbers of the dead, and St. Michael holding in his hands the balance wherein the souls are weighed.

The fifth capital presents to our view an angel listening to the sound of the trumpet; a large and brilliant cross sustained by other angels; our Saviour in a majestic attitude; human figures, some of which appear to have a joyful, and others a sorrowful expression. The artist has really shown considerable talent here, in thus sculpturing upon the one capital all the principal circumstances of the Last Judgment.

Finally, in the sixth capital, which is the first on the right hand, is portrayed the embalming of our Lord by holy women; the Saviour in the tomb, the guards around the sepulchre, and the issuing of the souls of the dead from Hades. This tomb has some analogy to the most ancient churches; it is surmounted by a small square tower.

Thus, although smaller than the church of le Port, which is ten metres longer than that of Issoire, St. Nectaire, by its very remarkable interior decoration, by its complete isolation, by its site, and the deep precipices which adjoin it on the south, the east, and the west, by its fine state of preservation, and the completeness of its Roman origin, in one word, by its architectonic characters, and the monuments which adjoin it, as well as by the historical recollections which are attached to it, is an object of much interest, and is one of the few religious edifices in this department (Puy-de-Dome,) which deserve the attention of archæologists and of the Government.

During the revolution, the upper story of the tower was thrown down, and one of the arches of the porch was entirely demolished. This has left a crack, which extends on the arch of the nave as far as the transept, and which has even attacked the cupola. The commune of St. Nectaire is so poor, and, indeed, has so little idea of the value of its church, that the rain is thus allowed to penetrate in all parts, threatening other portions of the structure with speedy dissolution, and repairs of the roof, the porch, the cornices, and other parts are imperiously demanded. The steeple, too, and the south door require to be repaired, and the soil around the church should be raised.

Other monuments, of different kinds, and of various epochs, scattered through the commune of le Nectaire and the adjoining ones, impart a new interest to the one on which we are engaged. We can, however, only point out a few of the most important ones.

We may first remark a chapel in the form of a small Roman church, situated in the cemetery on the north of the church of le Nectaire. This was formerly a baptistery. Here masses for the dead were cele-

brated, and a lamp was kept constantly burning. This little edifice is now used as a receptacle for human bones. Another chapel, also Roman, and very remarkable for its circular form, its columns with capitals, its plinths, its brackets, and its diminutive windows, is situated in the cemetery of Chambon, a league and a half to the west of le Nectaire; it is consecrated to John the Baptist. This chapel, which is also an ancient baptistery, represents upon one of its capitals St. John, placed between the two Testaments, according to the christian doctrine. To embody this idea, the artist has roughly sculptured, on the right of the saint, the ceremony of circumcision, emblem of the ancient law; and on his left, the first miracle performed by our Saviour, that at the marriage of Cana. The same canton of Champeix contains some other chapels of this kind, which appear, like our ancient crypts, to have been destined to several purposes, and where it seems that the sacrament of baptism was sometimes administered by immersion or otherwise; this is proved by the large vessels which have existed in some of these little buildings, the wells and springs to supply which may yet be seen in the crypts at Clermont, Royat, Planzat, St. Cirgues, &c. Many of these springs, yet held in veneration, are found near most of our ancient religious edifices.

As to the other monuments of the Middle Ages which adjoin the church of St. Nectaire, the most remarkable are the remains of the old feudal castle on Mount Cornadore, where many habitations may be seen hollowed out in the volcanic ravines. It is called Chateau-neuf. But the majestic castle of Murol, about a league from St. Nectaire, one of the strongest and in best preservation in Auvergne, is well worth the numerous visits which are constantly paid to it.

Gallo-Roman monuments were very numerous in this canton; but most of them have been destroyed. I have seen the ancient baths constructed upon the warm springs of St. Nectaire, where so many invalids come to regain their health, and where men of taste were delighted to appreciate the church of Bourg. I cannot here describe these baths; but their construction, and the imperial medals which have been found in them, evidently point to their Gallo-Roman origin. I have even seen under some of these ancient baths, built of brick and Roman cement, a floor of travertin as a reservoir for mineral waters, under which were vestiges of baths built of wood and rough stone, of a still earlier date. In many other localities near St. Nectaire, Roman cement and bricks, and large flat tiles, are often met with. Some of them have been found in the church of Bourg, around the absidal chapels.

Large Celtic monuments, which have bid defiance alike to the attacks of the elements and of revolutionary violence, abound on these mountains, less populous and less cultivated than the fertile plains of Limagne. A fine granite dolmen is seen on a plateau which overlooks the ancient baths of St. Nectaire. The table is about 11 feet long by 7 wide, and is 2 feet thick. The opening looks to the east, inclining a little south, as in our other dolmens. Some metres from this, still on the granite soil, is another table in basalt, and some other druidical stones. We may here remark, that between these ancient monuments there exist vestiges of old habitations, the largest of which are about 12 feet square, and the smallest not more than 9. A wall protects the northern aspect of these huts. In the valley between the ancient baths and the town of St. Nectaire were two other dolmens. Between that town and the village of Farge is another, of the same dimensions as the largest of which we have spoken. Near Chateau-neuf are the remains of a table still larger, placed upon a small hillock in the form of a tumulus: a short distance from hence is a remarkable *men-hir*, on which a cross has been erected: this place is still called *la Fichade*. Druidical remains are also found on a plateau called Mercuro, near the village of Suchat. This department contains many mountains, whose names resemble that of Mercury, such as Mercural, Mercœur, Marcium, &c.: all of them present traces of Celtic and Gallo Roman monuments, besides remains of castles of the middle ages. On descending from St. Nectaire to Champeix and Neschers, we see another fine dolmen near the village of Chasoux, and between Champeix and Ludesse, a men-hir 11 feet high and 3 feet in diameter. It is also called the Fichade Stone. Between Ludesse and Neschers, another large dolmen has been uncovered: it is quadrangular, and its broadest faces look towards the east and the west. Other men-hirs, a trilithe, and some large rocking stones, one of which is accompanied by a semicircle of upright stones, or cromlech, are found in the commune of Allois, near St. Nectaire. But the most remarkable druidical monument of Auvergne is found in this same commune, near the village of Cournol. It is 30 feet long, and 10 broad. The opening, which is to the east, is formed of two stones, from which the monument enlarges on both sides, and a large block of granite is placed horizontally upon other stones of the same kind. There are other Celtic stones near Cournol, and a fine bronze hatchet, and stone hatchets and arrows, have been found there; also a bronze patera, on the handle of which is inscribed in Roman characters the word *Erotis*. This vase is very elegantly formed, and appears to be of the Gallo-Roman epoch.

I regret being unable to furnish more details of the numberless objects of interest which this canton presents, not merely to the archæologist, but also to the geologist, the botanist, and all others who cultivate the natural sciences. They may follow for four leagues from east to west, that is, from Neschers to Murol, by Champeix, Montaigut, Verrieres, St. Nectaire, and Salut, a series of lava currents which have flowed from the magnificent crater near Murol, called Tartaret, a name which, like many others in this vicinity, appears to indicate that the ancients had some idea of the nature of these volcanic eruptions, although the most recent of them occurred long before any historical records, as is further proved by the numerous extinct species of animals which have been discovered among the alluvions of the epoch when these eruptions took place.

All the savans of England, Germany, and France who have visited this department, and viewed the collections it contains, particularly the rich palæontological collection which has been sent to the Museum at Paris, have agreed that few localities in France are more deserving investigation than the environs of Nescher and St. Nectaire. I shall say nothing of the landscape painters and others who come to visit the beautiful cascades of the Couze, which are formed by the lava of Tartaret. Nor do they forget the beautiful lake of Chambon, which is contained in the triple crater of the same mountain. But still the church of St. Nectaire is the chief object which arrests their attention.

ABBE CROIZET.

M. Didron (secretary to the Historical Committee of Arts and Monuments,) adds, to the above details, that of all the churches of Auvergne, that of St. Nectaire is the richest in sculpture; and that, although the Abbé Croizet has reckoned only 150 figures of men and animals, the actual number far exceeds that amount. As to the chapel detached from the church, which is some paces from it, and raised above the cemetery, he considers it a funereal chapel, rather than a baptistery. In Greece, especially in the monasteries, there is constantly a chapel of a particular form, and of two stories, like that at St. Nectaire, which serves as a sepulchral chapel for the community, and often for the parish. It is surrounded by the cemetery on all sides. At the end of four years the dead are exhumed, the rest of the funeral

office is performed, and the remains of the corpses, reduced to bones, from which no dangerous exhalations can then arise, are deposited in the lower floor of the chapel, or crypt, as it may be called: the upper story of the chapel is used for reading the funeral service. Almost all the chapels of peculiar form, such as circular, prismatic, the Greek Cross, &c., have been used as funereal chapels, as the church of Sainte Croix, at Montmajour, of Aiguilhe, at Puy, and of Planes at Roussillon: their construction has been attributed to the Templars, but they certainly do not owe their origin to that body.

ARCHITECTURAL AND HISTORICAL NOTES UPON SOME OF THE PUBLIC AND PRIVATE BUILDINGS OF MILAN.

BY SIG. FERDINANDO CASSINA. NO. II.

Porta Romana.—*The Roman Gate.* This majestic entrance, built entirely of white marble, was designed by Martino Bassi, a distinguished architect of his age, and was erected in 1598, on the occasion of the reception of Margaret of Austria, queen of Philip the 3rd, king of Spain, who passed through Milan, on her way to Madrid. Over the gate there is the following inscription:—

Ingredere Læta Serenissima Margarita Avstriaca
Maxima, Pia, Felix, Avgvsta Amplissimam Italiæ Vrbem
Frequentissimo Exvltante Popvlo
Majestatisq: Tvæ Presentia, Tamquam Expectatissimo Trivmpho Gestiente;
vna enim omnivm voce virtvs ipsa loqvitvr, et prædicat,
Te Illam Esse Prætiosam Margaritam,
Quæ Philippi III. Potentiss. Regis Imperiv magnitvdine ampliat
Pondere Firmat
Candore vniversvm orbem illvstrat.

The inscription in the internal part is as follows.

Serenissimæ Reginæ Margaritæ Avstriacæ Ad Conjvgem Philippvm III. Potentissimvm Hispaniarvm Regem Et Mediolani, Dvcem Proficiscenti. Portam Hanc Trivmphalem Dicavit Civitas Mediolanensis. In Hanc Verò Pvlchritvdinem Extrvendam Cvravere Ex LX. Viris Sfortia Brippivs, Hermes Vicecomes, Renatvs Borromævs Comes, Hieronymvs Vicecomes Eqves, Hieronymvs Moronvs Comes, Georgivs Trivvltivs Senator et Comes; Ex Decvrionibvs Johannes Baptista Mandellvs J. C., Ricardvs Malvmbra J. C., Johannes Baptista Lvativs, Philippvs Catellanvs Cotta, Georgivs Irivvltivs Senator et Comes, Christophorvs Besvtivs, Georgivs Siccvs Comes, Petrvs Pavlvs Vicecomes, Johannes Pavlvs Fagnanvs, Johannes Baptista Fossanvs, Octavivs Piolivs, Octavivs Raverta, Tatio Mandello Comite Vrbis Præfectvram Gerente. Theodoro Calcho R. L. T. Magno Inclyto Principe Io, Ferdinandeo Velaschio Comestabili Castellæ, Vice-Regis Potentissimi Mediolanensem Provinciam Gvbernante Anno CIↃ. IↃ. 110.

Porta Dell' Antico Palazzo Di Cosimo Medici, Ora Vismara.—*Gate of the Ancient Palace of Cosimo Medici, now Vismara.* The palace of which this is the gate is situated in the street Bossi, and was given in 1456 by Francesco Sforza duke of Milan, to Cosimo Medici. Cosimo has the merit of having much enriched it, and of having built this gate, which is constructed of marble. Michelozzi was the architect employed in these works. Nothing more is now perceived of the ancient work than the court-yard, which has not changed its form. Here still colossal heads may be seen springing from between the arches in the portico substituted for the old ones in the cotto, now destroyed, by Signor Vismara, who committed the execution of them to the modeller Girola. There is also in the yard a picture much injured, representing a man of trade, who is reading before a counter; and this agrees with what Vasari says in the life of Michelozzi, that Cosimo had here his bank. In some of the rooms of the ground floor the marks or insignia of the Medici, the ring with a diamond and with a hawk, may be still seen painted on the walls and ceilings in square compartments of wood.

The marble gate is very well preserved. The piers on each side of the gateway in the elevation towards the street, are decorated at the bottom with two sculptured warriors, armed with the clavis. Above each of these there is a female figure supporting the ducal ensign of Sforza upon a lance, and the whole is surrounded by a pyramid of flowers, fruits, and birds, upon which is represented a playing infant. At the extremities of the frieze greyhounds are represented, under the laurel tree, the bearings of Francesco Sforza. Two winged figures in the centre support the shield of the Dukes of Milan. In the spandrils of the arch are carved the portraits of Francesco Sforza, and Bianca Maria Visconti his wife. The internal faces of the gateway are very beautifully decorated. Upon one is represented the oak, with a ring and diamond, with the motto SEMPER, and the mariner's compass, with the motto DROIT, all of which are marks of the Medici. On the other is represented a peacock, the crest of the Dukes of Milan, with the motto REGARDEZ-MOI.

This palace passed from the Medici to the Count Barbò, by whom it was sold in 1802 to Pizzoli. In 1821 it was bought by Signor Carlo Vismara, and is still in the possession of his family.

Chiesa di S. Fidele. *The Church of St. Fedele.*—This church is erected on the site of the ancient church of St. Maria, in Solariolo. The ancient structure was presented by St. Carlo Borromeo to the Jesuits; and on this occasion the new church was erected. Pellegrino Pellegrini was the architect of this magnificent temple, but Martino Bassi was engaged to some extent in finishing it, Pellegrini being compelled to leave Italy to superintend some works in Spain.

The first stone was laid by Charles Borromeo, the 5th July, 1569.

The church was abandoned by the Jesuits on the occasion of their suppression in 1773, and not many years after the ancient church of St. Maria della Scala, which was the church of the court, being converted into a theatre, the clergy connected with it were transferred to that of St. Fedele. This collegiate establishment was ultimately suppressed, and no vestige of it remains but the title of Provost still retained by the curate.

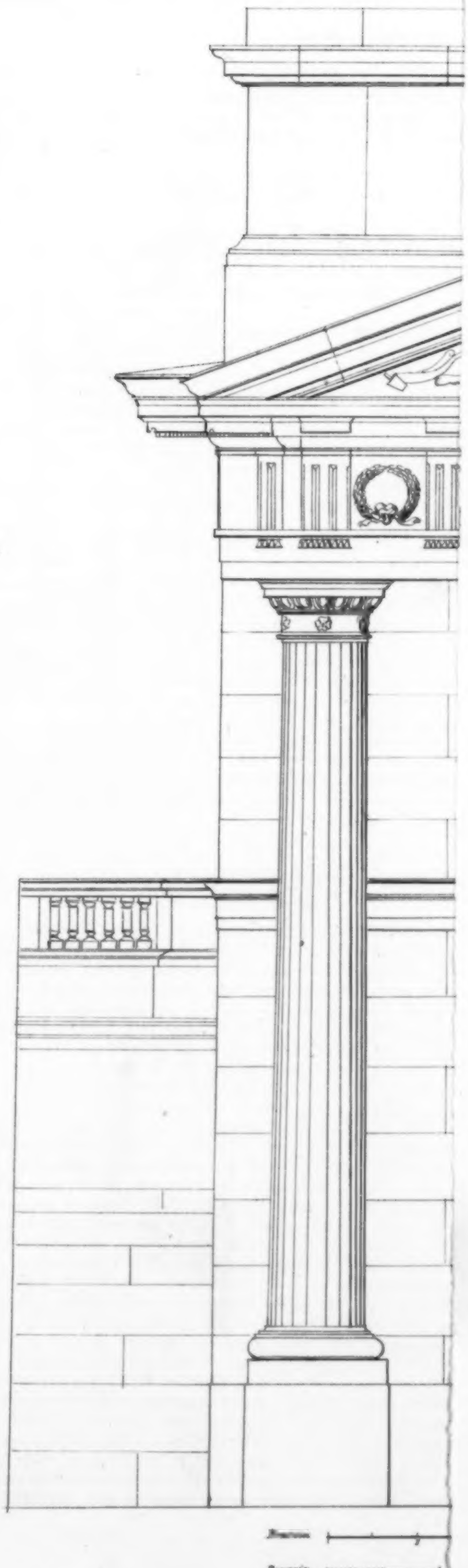
Although this church was opened for public worship ten years after the first stone was laid, St. Charles being present on the occasion of the first celebration of mass, in 1579, it was not at that time quite finished. The back elevation is still incomplete, but it will probably be undertaken by the inhabitants of the city at no very distant period. The facade remained for some time in an unfinished state, the pediment not being erected. Neither were the two bassi-rilievi in the superior order provided, nor the statues for the niches. To the energy and care of D. Giulio Ratti, the present provost, the Milanese are indebted for the completion of this elevation, and for the basso-rilievo representing the ascension of the Virgin Mary, the work of that distinguished sculptor Gaetano Monti.

Count Francasco Aresi, who died on the 1st May, 1835, left to this church a sufficient sum to decorate the façade with the four statues that were wanting. These figures were entrusted to the most eminent sculptors residing in the town. The two in the first order represent the saints Fedele and Carpoforo, whose remains were deposited by St. Charles under the high altar when he laid the first stone of the church. They are the work of the same Gaetano Monti, who executed the large basso-rilievo in the tympanum of the pediment. One of the statues placed in the niches of the superior order, represents David, and was carved by Manfredini, the other represents Isaiah, and is the work of Sangiorgio. The sculptor Butti, of Viggiù, executed that basso-rilievo in the superior order which represents the burning bush, and the other which is from the history of Jacob is by Labus.

The direction of the architectural works executed on the occasion of the completion of this building was entrusted to Pestagalli, who designed the high altar, constructed in 1821.

The pulpit, the confessionals, and the wardrobes in the vestry, works remarkable for the beauty of the carving, were put up under the direction of the Jesuits, and are still in a perfect state. A reclining statue, recently found, and supposed to represent Carlo Mauro, who at his own expense built the college of the Jesuits near the Church, and now used as the offices of the census, is placed near the entrance of the vestry.

Anfiteatro di Milano. *The Amphitheatre of Milan.*—This ample and sumptuous amphitheatre, called the arena, in the piazza d'Armi, was designed by Louis Canonica. It was erected to supply the place of the temporary amphitheatres of wood employed for the games which, in the beginning of the late Italian government, were



THE TRIUMPHAL GATE OF TH

…OF THE AMPHITHEATRE OF MILAN.

Newworthy & Wells Litho Union St Little Moorfields.

commonly given to the public. It was designed in 1805, and the erection was commenced in 1806, and the works were carried on with such celerity, that in the autumn of 1807 it was opened, a large portion of the materials from the destroyed fortification of the castle being employed in the construction.

The poulvinare and the triumphal gates were not finished till the year 1813, and the carceri (prisons or stables) were not completed till 1827.

The amphitheatre is 238 metres long, and 116 broad, and will contain upwards of 30,000 spectators. It serves the public for horse and chariot races, and for gymnastic games, and also for boat races, for by the arrangements which have been made the area may be filled with water in a short period of time.

The poulvinare is a remarkable feature in this amphitheatre. It is of an elegant form, and is destined to receive the royal family and the most distinguished nobles. The carceri serve as shelters to the horses and to the persons engaged in the amusements.

The entrance to the amphitheatre is by three principal gates; one is called Triumphal, another Libitinaria, and the third the Gate of the Carceri. There are also eight minor entrances which lead to the raised seats, and two others which bring the visitors to the steps of granite above the carceri. To enter the podium, which is near the area, and at the foot of which there runs a rivulet or small canal for the games of boats, there are four staircases, two placed in the interior of the triumphal gate, and the other two at the opposite parts of the carceri.

The triumphal gate and poulvinare deserve particular attention. The first is in the Doric order and is built of granite, with four columns elegantly carved, and in the tympanum there is a basso-rilievo, the subject of which is an allusion to the ancient races. It is carved in marble, and is the work of Gaetano Monti of Ravenna.

The poulvinare is a beautiful architectural design, and is imposing for the magnificent portico raised towards the interior of the amphitheatre. It is entirely formed of red granite. Four of the eight columns were brought from the suppressed monastery of St. Philip; they are all polished and are in the Corinthian order. There is an ample flight of steps, also of granite, under the poulvinare, which forms an order of seats for the royal suite.

THE CARTOONS.

(FROM A CORRESPONDENT.)

The exhibition of the cartoons in Westminster Hall is a grand and startling revelation of British art. To speak of these drawings in the same style of language as we are accustomed to describe other pictorial exhibitions, would be to insult them and dishonour the arts, for no terms of praise can give an idea of their merits. He who visits Westminster Hall expecting to find a holiday show, a gay assemblage of exhibition pictures, or even designs, suited to the taste of that large proportion of the public who are best pleased with the broadest vulgarities, will be woefully mistaken. The cartoons must strike the most unthinking with the idea that something great and noble is before them; but to appreciate the merits of these designs, and more particularly to distinguish the gems from their less brilliant companions, the mind must have been cultivated and made familiar with the highest order of composition.

The place chosen for this exhibition brings before us many of the historical scenes enacted within its walls, and but few of the many purposes to which it has been devoted are so worthy the hall of Rufus as the present. The enclosed portion is divided longitudinally by a screen, which nearly doubles the area for hanging the cartoons, and forms, as it were, two distinct galleries, each about 200 feet in length by 30 feet in width. Light is admitted through windows opened in the roof, subdued and quiet, yet powerful enough, and far more pleasing to the eye than any greater glare could have been.

The first object of Government in giving notice for the cartoons, was to inquire whether fresco-painting might be applied with advantage to the decoration of the Houses of Parliament; and although some years must elapse before the walls of the new buildings can be in a fit state for paintings of any kind, yet, as fresco-painting had not been much practised in this country, and as candidates for employment may find it necessary to make preparatory essays, Her Majesty's Commissioners gave notice, that three premiums of £300 each, three of £200, and five of £100, would be given to the artists who should furnish cartoons deemed worthy by the appointed judges.

The drawings are in chalk and charcoal, and entirely without colour; in size not less than ten or more than fifteen feet in their longest dimension, and the subjects are selected from British history, or the works of Spenser, Shakspeare, or Milton.

The arrangement of the pictures is excellent. Those from the poets are placed apart from the historical. Subjects from Spenser are placed near the door; those from Skakspeare are next to them; and further on are those selected from Milton. The other side and the centre screen contain the historical pictures, in periodical groups, commencing with Julius Cæsar's invasion, and terminating with the 17th century. There are only a few exceptions to this, and the best productions are almost in every instance placed in the lower range. As all the pictures sent in competition have been exhibited, it is not surprising that some are without a qualifying expression "bad," but any one from the majority in any other exhibition would show itself as a star, and attract attention accordingly; but in a constellation of poetical and historical compositions like the present, many that might elsewhere shine "as bright particular stars" are overlooked. If some of the prizes of the fourth class have been bestowed upon artists, the merits of whose works will admit of a question, it still cannot be denied that much judgment and impartiality have been exercised, under circumstances in which both must have been severely tested. In the original awards, we believe, with the exception of one of the third class prizes, there was a unanimity of opinion among the judges.

It is worthy of remark that those to whom the original premiums have been awarded are men either hitherto absolutely unknown, or of little celebrity, which is in itself some proof that the prizes have been bestowed impartially, that the discovery of merit has been the principal study, and, in fact, that for once in the history of competitions personal interest has been disregarded.

The successful pictures are, No. 64, Cæsar's first Invasion of Britain, by Mr. Edward Armitage; No. 84, Caractacus led in triumph through the streets of Rome, by Mr. George Frederic Watts; and No. 105, First Trial by Jury, by Mr. Chas. West Cope, for the premium of £300. No. 100, St. Augustine preaching to Ethelbert and Bertha, his Christian Queen, Mr. John Callcott Horsley; No. 124, The Cardinal Bouchier urging the Dowager Queen of Edward IV. to give up from sanctuary the Duke of York, by Mr. John Z. Bell; and No. 128, The Fight for the Beacon, by Mr. Henry J. Townsend, for the premiums of £200. No. 10, Una alarmed by Fauns and Satyrs, by Mr. W. E. Frost; No. 70, Joseph of Arimathea converting the Britons, by Mr. Edmund Thomas Panis; No. 78, Boadicea haranging the Iceni, by Mr. H. C. Selons; No. 104, Alfred submitting his code of laws for the approval of the Witan, by Mr. John Bridges; and No. 111, Eleanor saving the Life of her Husband (afterwards Edward I.) by sucking the Poison from the Wound in his Arm, by Mr. Joseph Severn, for the premiums of £100.

The first-class prize, No. 64, has boldness and correctness, even to severity, in its composition; the conception is good, though neither grand nor imposing. The grouping is confused and is too much studied. It has great merits, but its merits are those of the French school. Nor can it, in our opinion, be compared to Mr. Watts' noble, simple, and pathetic picture. Who can look on Caractacus without feeling deeply impressed by his agonized countenance, his lofty bearing, and dignified though silent reply to the insults of his conquerors? and who can refuse sympathy for the indignities offered to his family? The youngest child clings to its mother for protection, and the elder sons shrink from the insulting gaze and savage exultation of the Roman multitude; but in the countenances of some of these we observe the traces of pity, for to the knowledge of his art Mr. Watts has added a knowledge of human nature. In this picture there is no attempt at display; it is the simplicity and perfect poetry of the composition which fixes the admiration.

No. 105, would by itself have commanded high praise, but it is not equal to the two former works; Mr. Cope might have done better. The cartoons for which the second and third class premiums have been awarded, can hardly be called inferior to the first; indeed, No. 78, a third class prize, is so dazzling at first glance, that it requires a cool head to prevent the observer from being carried

away by the energy of action and the effect of light and shade, and to avoid giving a decided judgment in its favour, without examining minutely into its details and expression, which are not equal either to the drawing or the composition.

In the short period of twelve days, during which the exhibition of the cartoons was open on payment of 1s. each person, the visitors averaged 1,800 a day, and the whole sum taken exceeded 1,100*l*., nearly all of which has been divided among the following ten candidates, forming the fourth set of premiums, the number and subject of whose cartoons are as follows:

No. 11.—Una coming to seek the assistance of Gloriana, an allegory of the reformed religion seeking the assistance of England, from Spenser's Faëry Queen.—Mr. Frank Howard, Jun.

No. 13.—The seven Acts of Mercy: Una and theRed Cross Knight led by Mercy to the hospital of the Seven Virtues.—Mr. G. V. Rippingille.

No. 16.—The Death of King Lear.—Mr. F. R. Pickersgill, Jun.

No 31.—The Angel Raphael discoursing with Adam; Milton's Paradise Lost.—Sir W. Ross, R.A.

No. 45.—Man beset by contending Passions.—Mr. Henry Howard, R.A.

No. 60.—The Brothers releasing the Lady from the Enchanted Chair: Milton's Comus.—Mr. F. R. Stephanoff.

No. 63.—The Brothers driving out Comus and his Rabble.—Mr. John Green Wallen.

No. 92.—St. Augustine preaching to the Britons.—Mr. W. C. Thomas.

No. 103.—"Alfred, a Harper, went into the enemy's camp, where he was everywhere admitted: having thus acquired a knowledge of their situation, he returned in secrecy."—Mr. Marshall Claxton.

No. 122.—The Plague of London, A.D. 1349: the bishops and clergy are represented at St. Paul's cross, praying for the cessation of the pestilence.—Mr. E. Corbould.

The exhibition is now open gratuitously every day in the week, except Saturday, on the afternoon of which day one shilling will be charged for admission.

C.

THE LIFE AND WORKS OF CAPTAIN JOHN PERRY.

BY W. MULLINGAR HIGGINS, ESQ.

The name of John Perry will always be honoured by British engineers, as that of a man of keen observation, and indomitable perseverance, possessing an extensive acquaintance with the subjects he professed, and a readiness of invention in the application of the principles of nature to scientific construction. At an early period of life he suffered a great reverse of fortune, and was oppressed by a punishment entailing professional disgrace, which he not only supported with fortitude, but, in a new sphere of life, by decision, energy, and genius, availed himself of opportunities of extensive employment, which brought him great honour, though he failed, as many other men of science have done, in securing wealth. He is best known to the profession in the present day, by his successful design for stopping the breach of the Thames at Daggenham, in which he ultimately succeeded, after contending with many unexpected difficulties. The circumstances which led him to this undertaking, the mode in which he proposed to acomplish it, the accidents which happened during the execution, and the manner in which he met them, are very clearly stated in the account he has left us in a small volume published soon after the completion of the work. But there are few persons in the present day who have any knowledge of the history or professional character of John Perry beyond that which may be collected from this volume, and the book itself is so scarce that it is probably unknowwn to many who take an interest in the enginering history of the country. A short account of this eminent man, and of the works in which he was engaged, will not therefore be uninteresting, and will perhaps tend to throw some light upon the state of professional knowledge at the period in which he lived. It is especially fortunate for the acccomplishment of my design that Perry continually alludes in his published writings to the most remarkable events of his life, so much so that he unconsciously wrote an autobiography—a consecutive history of his public and private life. From the commencement of his career, which was in the navy, he was the subject of misfortune, and the publicity of his disgrace enforced on his active mind the necessity of a public defence, and to the same tribunal he appealed in all the successive employments which engaged his attention. That the event to which I allude cast a gloom and a jealous apprehension of misfortune over the succeeding portions of his life is evident from every page of his books, for they all seem to be written to defend himself from some real or imaginary defamer. A man who in mechanical skill or constructive science goes before the age in which he lives must, in a greater or less degree, suffer from the jealousy, distrust, fears or mercenary opposition of his contemporaries. That Captain Perry was made the victim of all these distinct but equally prejudicial motives is quite evident from his history, and although he had the courage to remove the impediments thrown in his path, by a consistent and persevering application of his energies to the end he had in view, and to avoid a personal conflict with the individuals who thus attempted to retard his progress; yet he always stood in the attitude of defence. We should not be surprised if we heard him, in this state of mind, speaking in a fretful complaining tone, or giving expression to severe censures and condemnatory judgments upon the plans of those who opposed him—but this rarely happens. He may have been, as is too common among those who feel confidence in their opinions, founded upon the principles of nature, and tested by experiment, too confident of success, and have calculated below their true value the difficulties, impediments, and failures which would probably arise. His mind was naturally sanguine, and accustomed to overcome difficulties, which in his own individual case probably increased rather than diminished his exertions.

John Perry was the second son of Samuel Perry of Redborongh, in Gloucestershire, gentleman, and of Sarah his wife, daughter of Sir Thomas Nott, Knt. Of his early life I have been unable to collect any information further than that he was educated for the naval profession. In January, 1690, when lieutenant of H. M. ship Montague under Captain John Layton, he lost, in an engagement with a French privateer, "the use" of his right arm. The captain was killed in the beginning of the action, and Perry, having continued at his post for nearly an hour without giving time for his wounds to be dressed, was not expected to recover. In 1693 the Montague went into Portsmouth, and at that time Perry made some improvements in an engine then employed for throwing, in a small space of time, a large quantity of water from deep sluices. It would therefore appear from this fact, if there were no other evidence, that his mind was directed to engineering pursuits before he became professionally connected with them. It may be readily imagined, and there is probably some truth in the supposition, that nature gave a bias to his mind in favour of these studies, and that by constant observation and thought he prepared himself for those engagements in which he was destined to be, at a later period of his life, so actively and usefully employed. The event that introduced him was one of the most painful to the feelings of a man of honour, but having, as every candid reader must believe, fully discharged every stain upon his professional character, he entered with proportionate zeal upon new employments, for which he was well prepared by nature and study, and earned a lasting reputation.

In 1695 Captain Perry, at the time confined in the Marshalsea prison for the loss of a fire-ship, published a tract which he called,

"A Regulation for Seamen," which in fact is an argument against the disgraceful and unjust custom of pressing, and to this he has added a defence of his own conduct on the occasion, in mitigation of his sentence, which was a fine of £1000 and ten years imprisonment. The document throws such a pleasing light upon his character and the events of his life previous to his engagements as an engineer, that I am compelled to make a few quotations.

"I have lost the use of my right arm in the king's service, and since that have lost all that I had in the world when taken by the French, and I was carried into St. Maloes, and kept there a prisoner near five months, and had not Almighty God in his particular care and good providence in a wonderful manner preserved me, I had been no longer the object of any person's fear or prejudice; but thanks be to God who has preserved me thus far, and though he hath permitted me to fall, and now to suffer under my heavy sentence, I with patience submit to it, with this comfort and satisfaction, that I never was reputed a coward; and if I may trust to my own judgment of the late action for which I now suffer, I think I did my duty to the utmost of my power; and whereas it is a common saying after misfortunes to cry out, If we had known before what would have come after, we could have prevented it, or have done better; it happens not so in my case, for, as God is my witness, I know not how I could have done better; worse for me it must have been if I had acted otherwise than I did, for I was driven on the edge of two precipices, and if I had fallen either way it would have been my inevitable ruin, as may appear by my following case, which I would not in anywise have printed, had I not appeared in public in another matter, and therefore I thought it very requisite to take some notice of it, lest my silence, as to this matter, should be imputed to my guilt, which would have made me very uneasy, for though I patiently submit to my suffering, yet I cannot to my guilt. I hope this will not be thought any reflection at all upon that honourable court that tried and condemned me, for I cannot think that they acted contrary to their judgments in condemning me, but do believe that they were led to it through the defect and weakness of my defence, and the testimony of some prejudiced witnesses that were against me, which I cannot now particularly remember, but do believe that by my eagerness and endeavours to prove the ill-will, prejudice, and combination of those persons, I did neglect the more proper part of my defence that might otherwise have acquitted me.

"On September the 20th, being about twenty leagues distance south-west from Cape Clear, I was commanding the Cygnett fire-ship, under the command of Captain Wickham of the Diamond, who was my Commodore; at eight in the morning, the wind at north-west by west, we saw two sail right to windward, bearing down on us. I then made sail and spoke with Captain Wickham, and told him, I believed they were French, and that I was getting my ship in readiness; he said he believed the same, and directed me to lie under his lee quarter within call of him, and that if he would have me go upon service, he would loose his sprit-sail top-sail, and hoist it with the sheets flying, according to the written order, which I produced at my trial, and which he gave me some days before under his hand.

"About four hours after our first seeing the enemy they came up with us, the Diamond being then under her top-sail, and I (being a heavy sailer) under my top-sail with foretack at cat-head, both steering away north-east and by north. One of the privateers, called the Granado, first came up, and fired some guns at the Diamond on her weather side, whilst the other, called the Philippo, came bearing down after her, with his sprit-sail yard topped, as I then believed, to board her, according to all practice, on the weather side; upon which I called to my master and told him that I perceived the enemy was for boarding, and that I would be so too as soon as I had an opportunity, although I had no signal; whereupon he replied, if you please we will get our tacks on board, and be on board this ship, which was then right to windward of me about musket shot, standing towards the Diamond as aforesaid; and therefore I refused his inconsiderate motion. Upon the coming of the privateer, the Diamond set her fore-sail, with the tack at cat-head, and let fall her main-sail, and stood away without altering her course, when at the same time, he having the wind of me, he might have borne down to me at any time, and easily have brought me to windward, if he would have had me to have prevented the privateer from boarding him, as he hath since pretended, or have given me an opportunity to have burnt him. Seeing the Diamond thus to make sail, and contrary to my first expectation, seeing the privateer running up under her stern, to board her on the lee quarter, on which side the lower tier of guns was not out, I immediately ordered my main and fore-tacks to be got on board, my top-sails to be hoisted and mizen to be hauled aboard, and sprung loof as near as I could lie, so to gain the wind of the privateer, that I might be ready to clap her on board, then believing, that by that time I could gain the wind, the Diamond would have put off the privateer, and that then I might have a fair opportunity of burning him, whilst he lay becalmed, or before he could have gathered way from under the Diamond's lee; but finding the Diamond did not put off the privateer, as I and all persons present every minute expected she would have done, I was then resolved to burn him notwithstanding I had no orders, as he lay with his bow on board the Diamond's quarter, then believing, in that little time I had to consider of it, that as soon as I had set fire to the privateer, the men, to save themselves, must have run into the Diamond, and with such haste, that most of them must have gone without arms, and consequently have been forced to beg for quarter: this, as God is my witness, was then my thoughts and resolutions, but having gained the wind, and brought the privateer right a-head of me, not half a cable's length distance, we saw the Diamond's colours struck, and coming up very near, we perceived none but Frenchmen upon the deck, and no resistance made, and that the Diamond was lost: I then found my design ruined and prevented, and not in my power to recover the Diamond, neither could I do any injury to the enemy, unless at the same time I had sacrificed not only myself, but all my men, to the revenge and fury of the enemy, we having no ship, no refuge left for us to hope to fly to, that could have saved us from the pursuit and destruction of the other privateer, who all the time from the Philippo's boarding the Diamond, was very near us, and firing upon us with both their great and small shot; and finding thus that we could do no service, and that we had no power to escape or defend ourselves, we surrendered.

"But had I then burnt the privateer, it is very probable, as circumstances since appear, it would have been my utter ruin, though the enemy had given me quarter, for my commodore might have then said that I was the occasion of the loss of his ship, by telling that there was but a few men boarded him, that they were at close quarters, the enemy just ready to cry for quarter, and that then I came without orders or notice, and fired the privateer, put all his men into a consternation and dread of being burnt themselves, forced all the privateer's men into the Diamond, who, by their great numbers, overpowered them, and so they lost their ship; and that if I had stayed until he had thought fit to give me the signal, I might have done service and saved the ship.

"All which, though supposition only, I humbly offer to the consideration of the impartial reader, and whether the world would not have

easily believed such an allegation true, and that such a man of war could not have been otherwise lost so soon, especially to one privateer."

This unembellished and business-like description of the circumstances which led to the loss of the fire-ship commanded by Captain Perry, is sufficient to prove that he lacked neither courage nor ability for the duties entrusted to him. He seems to have been conscious that he was the victim of private jealousy and dislike, and in his defence he failed from being more anxious to expose the motives of those who charged him, than to give a reason for his conduct, and show the necessity of the course he adopted. The period of his imprisonment however was shortened, but whether this was in consequence of the publication from which I have quoted, I am unable to discover.

In 1698 Captain Perry was introduced to Peter, the Emperor of Russia, who was at that time in England, by the Marquis Carmarthen and Mr. Dummer, surveyor to the navy, as a suitable person to direct and superintend the formation of a canal between the Volga and the Don, a work which he was at that time about to commence. Perry was consequently taken into the service of the Czar, as comptroller of Marine Works, with a salary of £300 a year. For three summers he was employed in directing the formation of the canal between the Volga and the Don, and afterwards in various other engineering employments until the close of the year 1712, when he quitted Russia to return to his own country.

Of the various works in which he was engaged in Russia I shall hereafter have occasion to speak, but before I do so I will direct the attention of the reader to that great undertaking upon which his fame as an engineer has hitherto chiefly rested. It is fortunate that, in this attempt reference may be made to his own account of his labours, so that little more is required of his biographer than to arrange and quote the descriptions he has left.

About a fortnight after his arrival in London Captain Perry was taken down the river to see the works then in progress at Daggenham breach, by a gentleman "concerned in the endeavours which were then carrying on at the expense of the land owners." The state of the work at this period will be best described in his own words.

"At my arrival on the spot, I found upon the larboard or west side going into the mouth of the breach, a small sluice going then to be placed, of about three foot depth, and six foot width, in the area or passage for the water, and that the canal which was dug for placing down the sluice was not above three feet and a half depth below the surface of the marsh ground.

Upon my observing of this sluice, which was designed to be placed at no greater depth nor of no greater dimensions, I therefore, as I had resolved, without any reserve, told the aforesaid gentleman that in order to give the greater vent and ease to the passage of the water in the endeavours to stop the breach, I thought it would be proper to have had such sluice placed both to a greater depth, and of much greater dimension; but in justification of the placing of such sluice as it was begun, he replied to me that it was not the custom of the river to make sluices usually so large as that was, nor thought safe by workmen to venture to fix them any deeper, on account of the moor-log and bad ground, which made it esteemed to be impracticable. But these reasonings have since been confuted, in the practice of placing my sluices to the depth of the ordinary low-water mark (or very near it), as well as breadth proportionable thereto, being more than thirty times the dimensions in the area, and on account of the depth only, I am sure a thousand times more serviceable in stopping the breach, than the aforesaid trunk or sluice which they proceeded to fix could possibly be found.

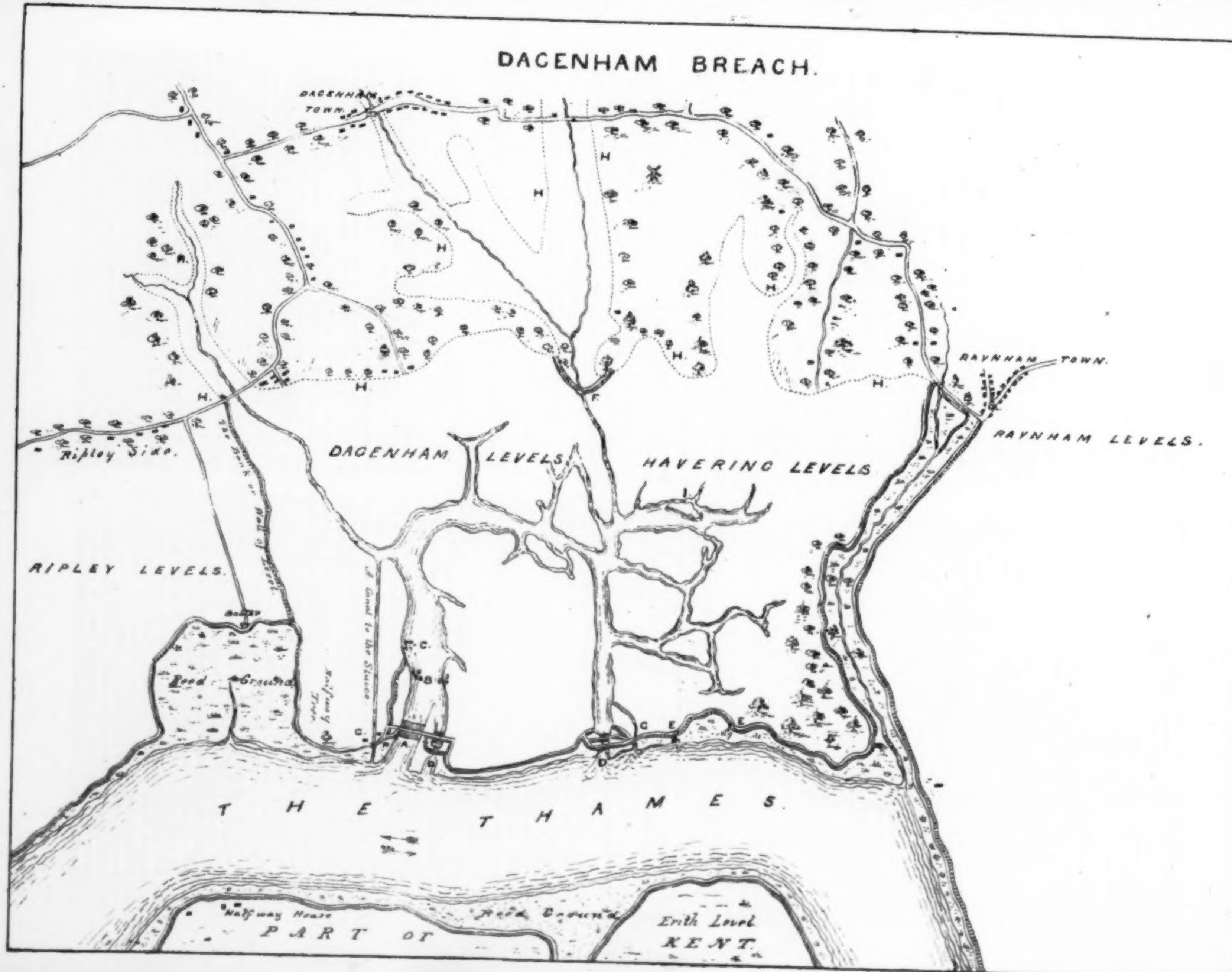
Being conducted by this gentleman farther on to the work, where they were endeavouring to stop up the breach, and being particularly informed by him of what they had done, in the various attempts made for it, with what they were then further resolved to put in practice: and having sounded the depths of the breach, and examined what I saw needful, it made me then change my mind of the possibility of their being ever able to make the work effectual, either by any method they proceeded in, or in the place where their designs were advanced, and ships and machines had been once sunk; this made me therefore reflect in my mind that I had been a little too hasty in so freely laying myself open in the point relating to the deficiency of the sluice they were about to place, and what was proper to be done for the discharge of the back-water, whereby they might, as I thought, easily have taken the hint, and have gone a great way in becoming masters of it; for since I believed that they must one day be obliged to begin the work again wholly in a new method, and in a new place, I thought it not at all reasonable for me (who had made this the peculiar business and study of the best part of my life,) to explain myself any further without a valuable consideration for it.

The method which I found they had from the beginning designed, and gone on in the labour of several years to stop the breach, was, (at letter C, in the draught or plan prefixed,) first, by the carrying out of piles, or drift-work, from the sides, until the passage of the water running in and out of the breach, became contracted and straitened, and then for the filling up of the remaining space that was left, they contrived the sinking of ships and other machines, and with a great number of hands for that purpose, threw in great maands or baskets, filled with chalk, and large bags filled with earth and ballast, &c, which baskets, with great quantities of loose chalk, bundles of hay, and other matters to fill up the interstices between the ships and machines which they had sunk, whereby they proposed to themselves to close the breach at once, and to give the water such a considerable stop, to a good height above the low-water mark, in the time of the neap tides, that they might be able to get above and overcome the force of the water, before springs came on.

The land-owners had that interest, that all the neighbouring country came in to assist them on these occasions, and it was common for men to stand in great numbers day and night, upon every reflux of the tide, up to the middle in water, not without the loss of many of their lives in the run of the stream in these attempts; for there being no sluice at all fixed that was of any service or use for the discharge of the breakwater for laying the work dry, there was at the time of the lowest ebb never less than two or three feet depth of water constantly setting with a fall over the works from out of the breach, whenever any degree of a stop above the low-water was made.

They several times by these methods, and by indefatigable application, thus brought their works near to a stop (they or persons employed under them), and still found themselves unhappy in the success, for when the passage was contracted, and the water came to be penned up to any difference of level, it penetrated with such violence either underneath the bottom of the ships and machines that were sunk, or on the sides of the breach, that it soon bored its own way, and drove all before it again, with such force, that it is not easy to be conceived nor described.

The penetrating of the water, either sometimes with greater force underneath the ships and machines which were sunk, and sometimes on the sides of the breach, tearing the same wider like a new canal, made them greatly complain of moor-log and quick-sand, saying, that they could easily stop the water, but they could not stop the ground, which constantly run away from them, whereas the only true way to stop the water was, first to have secured the ground; for by the sinking of ships and vessels, let the ground be ever so good, the water will bore underneath in some place or other, and it was a thing utterly impracticable for them to make the breach tight wherever ships or other machines were once sunk; and, therefore, when the gentleman who brought me down, with such other persons concerned whom I found at the breach, pressed me to give them my opinion and advice what they should do, I told them, that it was not in my power to give them any possible assistance to be depended upon for effecting the work, in the place and method which they had so far gone on with already, and that since they had spent so great sums of money, and brought their work so near for making the shut, as they then hoped for, I believed they would not willingly be persuaded to quit it, and to resolve upon raising a new and considerable sum to begin the work again quite in another method, and in another place, without trying the utmost in the method they were upon. I added further (as they pressed me to it), that it was possible they might make a stop in the way they followed, and raise up a dam by the mere strength of labour and application, but


DAGENHAM BREACH.
DAGENHAM TOWN.
RAYNHAM TOWN.
RAYNHAM LEVELS.
DAGENHAM LEVELS
HAVERING LEVELS
RIPLEY LEVELS.
Ripley Side.
The Bank or Wall of Level.
A Canal to the Sluice
Halfway Tree.
Reed Ground
THE THAMES.
Halfway House
Reed Ground
Erith Level
PART OF KENT.

that I did not conceive how it was probable such kind of work could be of any long duration, not only for the reasons above set forth, but also that the main body of chief matter of which the dam was composed being only chalk, the water would everywhere search and find its way through it, and must, upon the pressure of any high tide, endanger the same being thereby alone destroyed, though there were no ships at all sunk, or timber work in the foundation of the dam to lead the penetration of the water."

This breach, upon which Captain Perry was subsequently engaged as an undertaker, and from which he justly acquired a high reputation, was occasioned by the blowing of a small sluice or trunk which drained the low lands on the banks of the Thames. When the accident first happened, the breach was not more than 14 or 16 feet broad, "and might in a day or two days' time have been entirely stopped by the bringing on a small dam in form of a semicircle to the Thames wall, if many hands had been set to it; but through the neglect thereof, the constant force of the water setting in and out of the levels, soon made the gap wider, and when it once came to the moor-log, gravel, and sand which lie but a little below the common surface of the levels, the water then gulled to such a depth, and took such power, that there was no remedy found for the mastery of it." Perry did not see the breach till about fourteen years after the accident had happened, and the stream had then spread itself into several large branches, one of which was a mile and a half in length, and in some places from four to five hundred feet broad, and from 30 to 40 feet deep. A hundred and twenty acres of marsh ground were overflowed every tide. The task of draining this extent of land, and of closing the breach, was not, therefore, of easy accomplishment.

Breaches in the embankments of the Thames were about this period very frequent, arising sometimes from the failure of the walls, but more frequently from the decay of the sluices, which appear to have been universally constructed of wood. Perry has mentioned several instances: one at Limehouse, another in Long Reach, about two miles below Purfleet, which was not stopped for more than seven years, and a third in the levels of Daggenham-Beam.

(To be continued.)

ORDNANCE GEOLOGICAL SURVEYS OF ENGLAND AND IRELAND.

FROM MR. MURCHISON'S ANNIVERSARY ADDRESS TO THE GEOLOGICAL SOCIETY.

Ordnance Geological Survey of England.—The progress which was confidently expected at the hands of the Ordnance Geological Survey, directed by Sir Henry De la Beche, has recently been so effectively extended to a country with great part of which I am well acquainted, that I take the opportunity to add my tribute to the large share of public approbation which such labours must earn for their authors. If my few comments on this subject involve reference to my own work, I trust the Society will believe that such allusions are made solely to explain the subsequent progress of other geologists.

In my last Address I alluded to the valuable researches of the Ordnance Geological Survey of South Wales, particularly in the great coal-basin; and I have now to speak of them amid the older rocks of Pembrokeshire and Carmarthenshire, forming the south-western tracts of the country termed the Silurian region. In the survey of that region, my chief object, as you know, Gentlemen, was simply to ascertain the general classification and right order of certain fossiliferous strata beneath the Old Red Sandstone. Having worked out the succession in typical districts in Shropshire, Herefordshire, Radnor, and Montgomeryshire, I afterwards traced them to the south-west, until I equally determined their relations to the superior deposits in the coast-sections of South Wales. Although the labours in the latter country were thus auxiliary only to those of the arena on which the classification was established, I have had great satisfaction in finding, that my chief boundary lines of Old Red Sandstone and Upper and Lower Silurian Rocks are pretty nearly those which resulted from the very systematic Ordnance Survey, the first corrected field-sheets of which Sir H. De la Beche has allowed me to view. This observation has reference only however to the developement of what may be called one zone of Silurian rocks, or that to which, as contiguous to the Old Red Sandstone, I gave my chief attention. Of the existence of true Silurian rocks to the west and north of a certain line which was set up as a descending limit in South Wales, I was, I confess, entirely ignorant. Finding no fossils in the few visits which I made to the west of that barrier in Caermarthenshire, which was provisionally agreed upon, and to the north and west of which all the country was ultimately to be explored by my friend Professor Sedgwick, we both of us believed, that such tracts, for the most part without fossils, were of higher antiquity than the Silurian districts, and that rising up from beneath, they might hereafter be found to contain other and distinct forms of animal life.

The inquiry of Sir H. De la Beche has dispelled our ignorance. Instructing a number of intelligent young surveyors how to apply trigonometrical mensuration to stratified rocks, and patiently following up each mineral mass through its change of conditions upon its strike and throughout every contortion, the Director of the Survey has now clearly ascertained that the rocks to the north and west of the Towey in Caermarthenshire, as well as those to the north of Haverfordwest in Pembrokeshire, instead of being an undefined assemblage, to which the term Cambrian had been applied, are in truth nothing but the very same Lower Silurian rocks which had been pointed out on the east and south, and which (the Llandeilo flags being much more important than the Caradoc sandstone) are repeated in great folds and undulations to the north and west. Often parting with their calcareous mater, these strata, often assuming a crystalline slaty cleavage, are in some tracts highly altered by the intermixture of trappean rocks, both of contemporaneous origin and subsequent intrusion. But in these altered rocks the Ordnance surveyors have detected true Lower Silurian fossils, and have thus, by zoological evidence as well as by geometrical admeasurements, convinced themselves that the rocks so very different in aspect, are nothing more than repetitions of the same fossiliferous strata which have been described upon the south and east. Such results, obtained amid strata so obscured by change, is one of the very highest triumphs of geological field-work; and I therefore wish to be foremost in recognising the deserts of the labourers who have obtained them among whom the Director particularly cites Mr. Ramsay, already so favourably known to us by his geological map and model of the Isle of Arran.

In looking at the Ordnance Maps of North Pembroke, which have recently been coloured, and will shortly be issued to the public, it is surprising to see how symmetrical order has been obtained out of such a labyrinth, and how the fragments and pieces of such a patchwork are brought together. I have the authority of Sir H. De la Beche to state, that in some districts the convolutions are so rapid as to reproduce the same band of contemporaneous trap, in perfectly parallel lines, no less than ten or twelve times in the width of a mile, whilst bosses of eruptive trap are so numerous as to defy analytical research. Although I only passed quickly over the tract of North Pembroke, and ought therefore, never to have added it to those portions of my works which were more carefully executed, I have still sufficient recollection of it to admire the beauty of the new delineations. If I may be allowed to suggest a parallel between it and districts which I have more minutely described, I am greatly mistaken if North Pembroke does not present phænomena almost completely analogous to those of the mineralized Lower Silurian rocks north of Builth in Radnorshire and at Cornden and Shelve in Shropshire, where numerous lines of contemporaneous trap alternate with Llandeilo flags and Caradoc sandstone, and where the strata on the flanks of eruptive rocks are the seats of lead and copper ores, the sandstone being often converted into a quartz rocks (Caradoc, Stiper Stones, Wrekin, &c. &c.). Combining the evidence of these tracts with those laid open by the extensive transverse sections which I formerly made in Montgomeryshire, in the north-western parts of the Silurian region, where the mases have been shown to roll over in great undulations from S.E. to N.W., I am fully prepared to admit the existence of a similar configuration in North Pembroke, West Caermarthenshire and Cardiganshire, districts with which I was very imperfectly acquainted, and where the aspect of rocks is at first sight, it must be admitted, very forbidding to those who search after fossil evidences. The greater, however, the difficulty, the greater is the merit of those who have solved the problem, and have thus established in parts of South Wales the precise relations of what were previously considered to be anomalous masses. The result of this Survey, up to the present moment, is, that in one small part only of North Pembroke is there any developement of rock older than the strata containing Lower Silurian fossils, and this

occurs in the promontory of St. David's, with which I am familiar: this rock, I can confidently say, is mineralogically undistinguishable from the close-grained purple greywacke of the Longmynd and Haughmond Hill in Shropshire; and in both the localities it has hitherto been found as void of fossils as in similar rocks of the Lammermuir Hills in the South of Scotland.

In the south-eastern parts of the Silurian region to which the Ordnance Geological Survey has also extended its labours, the accuracy of the chief lines which had been laid down, whether in May Hill, Usk, Woolhope, and the Malvern Hills, has been confirmed; and, under the vigilant eye of Mr. Phillips, some new species have been added to the former lists, both in the Lower and in the Upper Silurian rocks. Among the latter the *Pentamerus Knightii* has been found in a new locality, in the southern prolongation of the axis of Woolhope, thus showing how persistently the place of the Aymestry limestone is maintained; whilst a species of that remarkable shell, the Pleurorhynchus, has been detected in true Wenlock limestone.

In relation to the west flank of the Malvern Hills, Mr. Phillips has, by very close researches, come to an important conclusion. Certain specimens of a peculiar conglomerate or breccia having been found by his sister Miss Phillips, in which the *Pentamerus lævis* and other Caradoc fossils are associated with fragments of syenite, a further search was instituted, and a small boss of this rock was laid bare on the very edge of the syenite and in a vertical position, like most of the beds of the same formation along the north-western prolongation of these hills. The conclusion drawn by Mr. Phillips is, that a portion at least of the crystalline Malvern chain was in existence when the Caradoc sandstone was formed, an inference which is strengthened by the finer-grained adjacent and regularly-bedded varieties of the sandstone containing similar minutely triturated, igneous materials. At the same time it is certain, that the great upheavals of the syenite and trappean rocks took place long after the deposition of the Silurian strata, and even after that of the old red sandstone and coal measures, which at various points along this ridge, and particularly at the Abberley Hills, have been violently dislocated in contact with such intrusive rocks. The discovery on the west of the Malverns is, however, analogous to what has been observed along the flanks of the granitic axes in the Highlands of Scotland (Ord of Caithness, &c.), where fragments of rocks derived from them are imbedded in the old red sandstone conglomerates, thus showing an original crystalline nucleus, followed by other granitic eruptions. The isle of Arran offers proof of such a period of activity, which it has been inferred was posterior to the contiguous red conglomerate, in which no granitic fragments are imbedded.

When he pursues his researches to the northern parts of the Silurian region, Mr. Phillips will then see, on the flanks of the Breidden Hills, evidences nearly analogous to those which he has so well described in the Malvern Hills, and where it has been shown, that along a very ancient fissure of eruption, molten matter was consolidated before the existence of the Silurian rocks; that other eruptions followed, and were in continuous activity during the formation of the Lower Silurian strata; that again other upheavals took place by the rise of intrusive trap, which threw the previously formed contemporaneous plutonic deposits upon their edges; that the coal-measures deposited unconformably on such uplifted strata were afterwards deranged; and finally, that along the very same line of eruption, igneous matter, undistinguishable in mineral composition from that which had affected the ancient rocks, had cut its way in irregular dykes through the new red sandstone, and, from the isolation of a deposit of lias, was probably ejected subsequent to the accumulation of that deposit.

Such facts are, it seems to me, miniature counterparts of the upraising at successive periods of mountain chains; and the grand phenomena of the Caucasus, the Alps, and the Pyrenees may nearly all be studied in our small English ridges, and some of them peculiarly well upon the flanks of the Malverns, and their continuation the Abberley Hills.

In the sequel I shall have occasion to speak of other important researches of Mr. Phillips. For the present, then, I take leave of the Ordnance Geological Survey, assuring this Society, that having during the past year, for the first time, seen the practical application of the admirable method of field-survey which has been instituted by Sir Henry De la Beche, I am convinced that it will not only act directly as a great national benefit, in making more correctly known the structure of subsoil, in a manner beyond the reach of private enterprise, but that it will materially tend to elevate Geology, by connecting it in a permanent manner with Physical Science.

"*The Rocks of the Scottish Border*," and Mr. W. Stevenson's memoir on the Geology of Berwickshire are in the next place treated of; and the President then proceeds to notice the

Irish Ordnance Geological Survey—Tabular List of Irish Fossils.—A compendious volume, entitled 'A Report on the Geology of Londonderry, and parts of Tyrone and Fermanagh,' has just been published by our associate Captain Portlock, R.E., employed in the Irish Trigonometrical Survey. Illustrated by a geological map, numerous coloured sections, and plates of organic remains, this closely packed volume, of nearly 800 pages, is a sample of how great a mass of matter may be derived from a small district. Not having had sufficient time to study the details of this work, I must crave the author's indulgence if I refer only to such parts of it as have arrested my attention. Captain Portlock, having some time ago discovered a small patch of Silurian rocks in the region of his official labours, commenced a careful and systematic inquiry into the nature of the Trilobites with which it seemed to abound, and he now presents us with some very valuable results. In a preliminary discourse he offers many important remarks upon the affinities and anatomy of this group of animals, and after a very elaborate comparison of all the forms which he could detect in his district with those published by British and foreign authors, citing among the latter several works very little known to us, he arrives at the conclusion, that of sixty species in this palæozoic tract, fifty-two belong to true Silurian strata (for the greater part Lower Silurian), and eight only to the enormously developed carboniferous limestone of the North of Ireland. This fact is quite in accordance with what has long been my belief, that the Silurian or oldest palæozoic group is the great centre of Trilobitic life. Describing many new forms, which are figured, he establishes several new genera, among which the Rhemopleurides, obtained from the Lower Silurian Rocks, is a very curious and apparently quite distinct trilobite. There are but small traces of Upper Silurian or Devonian deposits in this district, the greater part of it being covered by a carboniferous series, consisting, as the mountain limestone of Ireland is known to do, of much sandstone and slate as well as limestone. Finding in it several shells which are eminently characteristic of the lower as well as of the upper beds of that great formation, he infers, and I think with perfect justice, that the mountain limestone of the North of Ireland must be compared with the whole and not with the upper part only of that formation in the North of England; an opinion I am prepared to support, by having found last summer several shells (notably the *Sanguinolaria undata*), which are published by Captain Portlock from the North of Ireland, in the very bottom beds of the limestone of Berwickshire and Northumberland. Confining myself to the researches of this author in the palæozoic rocks, on which he has shown so much skill, I must also request my hearers to consult this volume of the Irish Geological Survey, for much information respecting the overlying strata, among which some new features of the Keuper formation are sketched with the author's usual fidelity.

From the researches of Captain Portlock I turn to those of Mr. Griffith, who spent many years in preparing the Geological Map of Ireland, and for which he has deservedly received much praise. In a very elaborate comparative table of the fossils of the mountain limestone series of Ireland, presented to the Manchester Meeting of the British Association, Mr. Griffith divides that series into five subformations, which in ascending order are the Yellow Sandstone, Carboniferous Slates, Lower Limestone, Calp, and Upper Limestone. He also shows that the two lower of these subdivisions must, from their fossils, many of which ascend into the overlying strata, be classed with the mountain limestone series, and not with the Devonian rocks; in which case, I would observe, that they must also be classed with the sandstone, limestones and shale of Berwickshire, to which allusion has already been made. I am the more induced to believe in the accuracy of this comparison, because Count Keyserling and myself have this year confirmed the observation of Professor Sedgwick, made in 1828, viz., that Posidoniæ, similar to those in the culm limestones of North Devon, exist in the middle of the mountain limestone series of Northumberland. As Mr. Griffith has shown that the Irish Calp, which also occupies the middle place in the limestone of Ireland, contains the same peculiar fossils, the parallel may now be considered as very well established, between this central mass of the mountain limestone in these distant localities.

Drawn up as this table has been under the directions of Mr. Griffith, by a diligent young naturalist of good promise, Mr. F. M'Coy, there can be no doubt that it is entitled to much consideration, and that its publication will be very useful. In reference to the comparison instituted by Mr. Griffith between the strata of North and South Devon and those of Ireland, I may observe that it is of infinite importance to the establishment of a true series of equivalents, that large adjacent tracts of country should be surveyed, and their fossils compared by the same observers, for the want of which identical species may sometimes obtain different specific names; thus considerably interfering with a nice discrimination of the groups.

AN ACCOUNT OF THE RECLAIMING AND DRAINING OF LAND IN THE BEDFORD LEVEL, COMMONLY CALLED THE GREAT LEVEL OF THE FENS.

BY HARDY WELLS, C. E. AND SURVEYOR.

(*Continued from p. 177.*)

It has been said, with much truth, that man requires the aid of experience before he is able to bring his works to any considerable degree of perfection. This remark is peculiarly applicable to the work of drainage in the Fens, for though much ingenuity and judgment were exercised from an early period, the plans that were adopted failed to produce the results that were expected by the Bedford Level Corporation. The waters of the Middle and South Levels were not discharged by the Ouse Outfall at Lynn so swiftly as was anticipated, and though all the engineers who were consulted agreed in the opinion that the great impediment to the outlet of the waters was the wide, crooked, and shallow channel of the river Ouse, near its mouth, in passing from St. German's to Lynn, the remedy was violently opposed, and even after the production of Mr. Watte's Report, which was made by the general wish of the land-owners, his advice was rejected. After the trial of many partial means, all of which failed, the son of Mr. Kinderley, who first proposed a new cut, ventured to revive the same plan. But the delay of a hundred years was scarcely sufficient to mature the plans and silence the litigious objections of those who, for a temporary interest, were opposed to this measure.

In the year 1793, Mr. Wells (the grandfather of the author of these papers), surveyor to the Middle Level, and Mr. Soames, an officer in the Middle Level, sent letters to the Corporation upon the condition of the Level and the country in general, at which time a considerable part of the Fens, though the great banks had not given way, were under water, from the downfall. The state of the Fens at this time they attributed to the width of the channel below German's bridge, and the consequent decay of the outfall to sea by Lynn. In 1795, it still being the wish of the country that the Eau Brink Act should be proceeded with, a Board of the Bedford Level Corporation was holden to take into consideration the joint Report of Sir Thomas Page, Kt., and Mr. Mylne, engineers, on the intended cut, of which the following is a copy:—

London, March 6, 1795.

Minutes of proceedings on, by and between Sir Thomas Hyde Page, Knight, of the Royal Engineers, for and on behalf of the Mayor, Corporation, and inhabitants of Lynn, on the one part, and Mr. Mylne, civil engineer, &c., for and on behalf of the delegates appointed by and acting for the Committee of Landowners and other persons interested in the drainage of the Fens and inland navigation, between Lynn, Cambridge, and other places, of the other part.

First, a minute made at a meeting held at the White Hart, at Newmarket, on the 27th December last, of delegates from Lynn and from the Eau Brink Committee, was read, in the following words:—It is the opinion of this meeting, that it would much conduce to unite the country in the adoption of a plan for the improvement of the drainage and navigation, if two gentlemen of skill, one to be named on each side, should meet and consider of such measure, as they can concur in recommending to the country, and with that view, it is agreed that Sir Thomas Hyde Page and Mr. Mylne shall be requested to meet as early as possible for that purpose. That Sir T. Page and Mr. Mylne be desired to view such parts of the country as they may think necessary, and to direct their attention to the outfall below Lynn, as well as to the harbour and the river above.

Secondly. The present state of the Fens; the rivers running through them; the inland navigation and drainage of the country; the outfall of the Ouse; the haven of the town of Lynn, and the present state of navigation between the said harbour and the open sea, were taken into full and repeated consideration. Thirdly. The several plans and different schemes for the amendment of the drainage and navigation of the several parts and districts above, as well as the safety of shipping in the said harbour, and the prosperity of the important commerce of Lynn, and of the other towns connected therewith, were examined, weighed, and investigated. Fourthly, whereupon it was agreed that the whole extent of the present river Ouse, from Earith to Eau Brink, should be cleansed and scoured, and worked down to the greatest possible depth, and that allowed, every obstruction therein shall be removed, consistent with the safety of the banks, and the several bridges across the same. Fifthly, that the proposition of a new cut for the free passage of the navigation, and of the waters of the river Ouse, in an ample manner, and of dimensions sufficient thereto, shall be made from Eau Brink to the upper part of the harbour of Lynn, agreeable to the intention of the said Bill, the following conditions and matters being however adopted for the better effecting the several purposes of safety in the harbour, and for the better navigation and drainage meant thereby, videlicet, the banks of the present river, from the German's bridge to Eau Brink, and a certain portion of the upper end of the said new cut, shall be formed and laid down into one general and continued sweep or curve, of a regular circular form, to be described and set out with a large radius. The concave or west part of the said curve shall have the foreland 80 feet in breadth; and the curve or east side thereof shall have the forelands 60 feet in breadth, between the edges or sides of the middle or navigable channel, and the foot of the new banks to be constructed on each side of the said cut, and that the whole shall measure from bank to bank 370 feet in breadth at the upper end of the said cut. The middle part of the length of the said new cut shall be continued from them in a line towards Lynn, and shall be of an increasing width, in regular and uniform manner. The remaining part of the said new cut, downward to the harbour of Lynn, shall be so formed, that the extent thereof, taken together with the eastern shore, from thence to Sandringham Eau, along the front of the Ball wharf, and the other wharfs and shores, as far as the ferry staith, shall form one general and continued sweep or curve, as near to a true circular form as possible; and that the width of the channel formed by the said new cut, at the junction with the present channel, shall not be less than 278 yards; the present actual width of the narrowest part of the said harbour, at or near the ferry landing place. And moreover, that the said width at the said junction shall be divided out as follows: the internal slope of the banks shall not be less than 50 feet on the base line; the breadth of the east forelands shall be not less than 150 feet, and the west foreland not less than 100 feet. Sixthly, that the plans, figure, form, situation, and direction of the said new cut, in its whole parts and extension, together with the manner of its junction with the old parts of the river Ouse, between German's bridge and Eau Brink at the upper end thereof, and also between the parts of it and the Ball Wharf, at the lower end thereof, shall be set forth, marked, and staked out, on the spot, and in the several grounds and parts of the present river and its banks, by the said Sir Thomas Page and Mr. Mylne, personally, for the better security of the true intention and effect of the said plan being duly and truly put in execution. Seventhly, that the country or landed interest (represented as they are at present by the said delegates) shall concur in any measure for the improvement and better security of the harbour of Lynn, and the safety of the town and navigation from thence to the open sea, which may be proposed hereafter, and which shall receive the approbation of the said Sir Thomas Page and Mr. Mylne, jointly, due consideration by them being had thereupon. Eighth, and lastly, that all the other matters, things, and regulations contained in the said bill now depending, shall be carried into execution, and for the better satisfaction of the whole country and landowners interested therein, that both parties shall concur in obtaining the said bill passing into a law, for the immediate and effectual relief of the lands, fens, and marshes, oppressed, as they now are, by the late great floods and inundations.

To the Right Honourable Earl of Hardwick, &c., &c., and to the Worshipful Edmund Rolfe Elsden, Esq., Mayor of Lynn, this paper herein before recited and set forth, containing our joint opinions and report on the whole of the matters referred to us, is certified and submitted by

Your most obedient and very humble servants,
THOMAS H. PAGE.
ROBERT MYLNE.

It was ordered upon reading this Report that the Corporation funds be applied to cleanse, scour, and deepen so much of the said river as extends from Earith to Denver Sluice, so as to form an inclined plane, but nothing was actually decided upon about the new cut.

Soon after the production of the foregoing Report, plans were so far matured that an Act of Parliament was obtained, but still the works were not commenced, and the contentions of parties continued. The limited time (of five years) for the completion of the works was allowed to elapse without any practical operations being commenced, and the projected improvements lay dormant until 1806 and 1807, when another Act was obtained to extend the time. The engineers, Messrs.

Page and Mylne, having differed about the dimensions of the intended cut, the question was referred to and determined by Mr. Joseph Huddart, one of the elder brethren of the Trinity House, as umpire.

The award delivered by this gentleman recapitulates in technical phraseology the questions to be decided by him, and the circumstances under which his opinion was required. The document itself would have but little interest to the reader, and need not therefore be reprinted. The engineers between whom he was required to decide differed "as to the points of junction of the intended new river or cut with the river Ouse, at both ends of such new river or cut; and also as to the dimensions of the excavated part of the intended new river, and concerning the width of the forelands, and base of embankment at the lower end of the intended new river or cut; but they agreed that the width of such forelands and base of embankment shall be 278 yards from bank to bank at the top of the embankments." They also differed "concerning the slope or base of the embankments at the upper end of the said intended new river or cut." Mr. Huddart recommended that the point of junction of the intended new river with the present channel near King's Lynn should be 860 feet nearer the harbour of King's Lynn than a certain specified mark. The following are the dimensions he proposed for the new cut: The width of the navigable channel 296 feet; the east foreland 209 feet; the west Foreland 200 feet; the base or slope of the east embankments 64 feet; and of the west embankments 65 feet. The point of junction of the intended new cut with the present channel, at the upper end, near Eau Brink, be fixed 700 feet further up the river than a certain pole numbered 37 in the middle line. The following are the dimensions he recommended for the cut at this point:—The width of navigable channel 209 feet; the east and west foreland, as determined by Act of Parliament, severally 60 and 80 feet; the base or slope of the east and west embankment 13 feet each.

Soon after this award was delivered, Sir Thomas H. Page resigned his appointment, and upon the death of Mr. Mylne, the late Mr. John Rennie was elected to the office he held. In 1808 Mr. Rennie prepared drawings and specifications for the works he thought necessary. But the Navigation Committee appointed the late Mr. Telford, who consented to act in concert with Mr. Rennie. The following is the Report delivered by Mr. Rennie, after a general view of the works in the Middle and South Levels.

Report and Estimate on the Improvement of the Drainage and Navigation of the South and Middle Levels of the Great Level of the Fens, in consequence of a reference from the Honourable Corporation of the Bedford Level, made the 24th May, 1809. By John Rennie, Civil Engineer.

The drainage of the Great Level of the Fens, called the Bedford Level, is a work of the highest importance. The value of its produce to the kingdom is immense, even in its present imperfect state; but were the lands completely drained, I have little doubt its produce would be nearly doubled. The produce of 300,000 acres of valuable land must at all times be of great importance to the kingdom, but particularly so at present, when Great Britain is in some measure cut off from any communication with the continent of Europe, and her relations in respect to America are in a very uncertain state.

Many projects have been formed, and large sums of money expended for past ages, to effect the complete drainage of the Great Level of the Fens, but hitherto it has not been accomplished; and although much has been done, yet there still remains much to do. It is therefore with the greatest diffidence I venture to give my opinion, and although I do entertain a hope that the facts I shall state will bear me out in my conclusions, I am far from thinking that others may not form a better scheme, or make considerable improvements on mine.

The Great Level of the Fens is divided into three districts, called the South, the Middle, and the North Levels.

The South Level, including the high lands within its boundary, contains about 173,000 acres, and is bounded on the south by high lands in the county of Cambridge; on the east by those of the same county, and of Suffolk and Norfolk; on the north by some high lands of the latter county, and on the west by the old Bedford river.

The Middle Level, including the high lands within its boundary, contains about 120,000 acres, and is bounded on the south by high lands in the county of Huntingdon, on the east by the old Bedford river, on the north by part of Marshland and other low grounds, and on the west by Morton's Leam.

The North Level, including the high lands within its boundary, contains upwards of 50,000 acres, and is bounded on the south-west by the high lands of the soke of Peterborough, on the south-east by Morton's Leam; on the north-east by Wisbeach Hundred and South Holland, and on the north-west by the river Welland.

The drainage of the above three districts is effected entirely by the rivers Ouse and Nene, the former discharging its water into the great bay called Metaris Æstuarium, below Lynn, and the latter into the same bay at Cross Keys Wash, about ten miles below Wisbeach: but the objects to which my attention has been called being the South and Middle Levels, I shall confine my observations to those two districts, which drain by the outfall of the Ouse at Lynn.

The Great Ouse rises on the borders of Warwickshire, and in its passage through the counties of Oxford, Buckingham, Bedford, and Huntingdon, receives many subsidiary streams. At Erith it enters the Great Level of the Fens, and passes through the New Bedford river to Denver sluice, where it is joined by the Old Ouse, and from thence by the old channel to the outfall below Lynn.

The Grant or Cam rises in the county of Hertford, and in its course through the town of Cambridge to Clayhithe receives several subsidiary streams; here it enters the South Level, and proceeds by Ely to Denver sluice, being joined in its course by several small lodes, and by the rivers Lark, Brandon, and Stoke, and joins the Great Ouse below Denver sluice.

The rivers above described, rising at a great height in the interior country, and their courses, until they enter the Fens, being also high, the floods come down with great rapidity, and when they enter the low lands, where the fall is gentle, and the channels shallow and narrow, the water cannot get off; it therefore accumulates in the washes and against the banks, frequently making breaches, and overflowing large districts of land. This took place to such a degree in the spring of 1808, that damage was done to the amount of at least *one million*; but should even the floods pass off without making any breaches of banks, still much damage is occasioned, owing to the surface of the water in the rivers being so much above the level of the adjoining low lands or fens, whereby the gates of the sluices are kept shut, and the water accumulates in the drains, and even inundates the surface of the fen, so as to do very considerable damage, by soaking into the lands and delaying the operations of agriculture, so that if crops are got at all, the produce is light, and the corn is of an inferior quality. Land liable to be so injured by wet weather is therefore of far less value than it would be were the drainage completed, for the farmer might plough, sow, and reap at the seasons best suited to the routine of crops, for which the soil is adapted, and indeed, many thousand acres, now in a lost state, would be brought into tillage and produce abundant crops, which cannot now be cultivated at all, and many more which are now in a more perfect state of drainage, would be greatly improved. But in order to illustrate the subject more fully, I will state the imperfections of the present drainage under four distinct heads, and afterwards discuss each separately. These imperfections are,

First.—The obstructed state of the outfalls of the rivers.

Second.—The incapacity of the channels through the flat country to carry off the water in times of flood, and the obstruction occasioned by the contraction of the water-way at the respective bridges over the rivers.

Third.—From the surface of the water in the rivers being, in times of flood, so high above the surface of the Fen adjacent to them, and from the inadequacy of the drains to contain the downfall water while the sluices are shut by the floods, and of the contracted water way of the said sluices being unable to pass the water when the floods have subsided.

Fourth and last.—From the water which is discharged from the high lands skirting the Fen, which cannot be carried off in time by the drains, were even the surface of the water in the rivers sufficiently low to admit of the sluices running at low-water.

With respect to the first, namely, the outfall at Lynn, it has already been so ably and fully discussed by the engineers and others employed in the scheme of the Eau Brink cut, that it is not necessary for me to enter into it; suffice it to say, that I am most decidedly of opinion, unless the Eau Brink cut is made, no perfect drainage of the South and Middle Levels can be effected. If I have any objection to the scheme, it is that the works are not sufficiently extended downwards; but I am persuaded, if ever this cut is made as now laid down, its benefits will be so much felt by the proprietors of

land, the navigators, and harbour of Lynn, that in a short time it will be the unanimous desire of all concerned to extend it farther to seaward.

As to the second, the channel of the Ouse from Eau Brink to Denver is deficient of capacity in almost every part of it, and the sharp turn above Magdalen bridge is a great obstruction to its current. The water-way of the bridges is generally too small. The clear water-way of St. German's bridge is 159 feet

Magdalen bridge	160 „	
Stow bridge	130 „	6 inches
And Downham bridge	123 „	8 „

But the water-way of the latter is greatly obstructed by stumps of piles standing up in various parts of the bottom of the river.

The Hundred Feet river, from Denver sluice to Erith, is very unequal in its size. In some places the channel is of sufficient dimensions; in others it is full of shoals and too narrow, particularly at Welmore Lake, which acts as a dam, and occasions a speedy inundation of the wash, which, with a breeze of wind, does great damage to the banks; and at the breaking up of a frost they are so cut by the floating ice, that breaches are almost inevitable. The bridge at Mepal is likewise a great obstruction, having only a water-way of 54 feet.

The channel of the Old Ouse and Grant, from Denver sluice to Clayhithe, is also in many places very deficient in size, and full of shoals towards its upper end. Its course is likewise very crooked, and the current of the Lark, or Mildenhall river, at its junction, is directly in opposition to that of the Old Ouse. Below Denver sluice a bank is frequently thrown up by the water of the Hundred Feet river overriding that of the Ouse, by which the gates of the sluice are frequently shut for days together, during which time the water accumulates, and breaks or overflows the bank, and when the water of the Hundred Feet river subsides, or when the accumulation of the water in the Old Ouse is so great as to force the gates of Denver sluice open, it cannot get off so speedily as it ought, and therefore incalculable damage is occasioned.

Denver Sluice has three principal drainage openings, one lesser opening, and a pen lock. The three principal openings are together 56 feet wide; the lesser opening, called Russel's Eye, is 16 feet wide, and the Pen Lock 13 feet 5 inches. When I took the dimensions of this sluice, on the 25th July, 1809, there was 7 feet water on the cills of the drainage doors, and when the water was running at the strongest, it produced at the rate of 27,700 cubic feet per minute, but when it is considered that the doors are shut twice in every twenty-four hours by the tide, during which time the water accumulates, it will be found that the average produce is far short of what I have stated.

The day after I had measured Denver sluice, namely, the 26th of July, 1809, I measured the produce of the Hundred Feet river, and found it, where unaffected by the tide, amount to 19,000 cubic feet per minute. This produce, I apprehend, considerably exceeds that of the Old Ouse; and when also the shortness of the course is taken into account, and the few obstructions there are in it when compared with the crooked channel of the Old Ouse, no wonder need be excited by the fact of the flood water of the New Bedford rising much sooner at Denver sluice than the flood water by the Old Ouse, and thereby shutting the sea doors, and preventing its running.

The channels of the rivers Stoke, Brand, or Little Ouse, and the Lark, or Mildenhall, are also in a bad state, and so are the lodes of Swaffham, Burwell, Reach, and Bottisham; their banks are weak, and unfit to sustain the great pressure of water which comes against them in floods.

In respect to the third imperfection, namely, the surface of the water in the river being so high above that of the adjacent fens, the inadequacy of the drains to contain the downfall water while the gates of the sluices are shut by the floods, and the contracted water way of the sluices, I have to remark, that on comparing the levels of various parts of the Fens with the sections which have been made, I have found that in many places the bottoms of the rivers are nearly as high as the surface of the land to be drained, and in small floods the surface of the water in the river is much higher than the land, and wind mills are required to scoop the water out of the low grounds, which is a very imperfect and expensive mode of drainage; especially when wet weather is succeeded by calm weather, the mills cannot work, and therefore the water lies on the surface of the Fen, and does incalculable injury; whereas, had the capacity of the drains been sufficient, they would have acted as reservoirs, and received the water while the sluices were shut, and so prevented in part the injury to which the lands are now subject, and whenever the freshes permitted the doors of the sluices to open, the water so accumulated would have been speedily carried off, if the sluices were of sufficient capacity.

The sluices through which the Middle Level is drained are, first—The Old Bedford sluice, which formerly had two openings, but has now only one; it is 15 feet 10 inches wide, and its cill lies about 4 feet 1 inch above that of Denver.

Second,—Salter's lode sluice, which has one opening 15 feet 5 inches wide, and its cill is about 3 feet 1 inch above that of Denver.

Third,—The Tongs drain sluice, which has two openings of 12 feet wide each, and their cills are about 5 feet 3 inches above that of Denver.

These different sluices being added together, make a total width of 55 feet 3 inches. Now this width is certainly more than sufficient to pass all the water of the Middle Level, were the surface of the river sufficiently low to admit the gates to open fully; but when the crooked line of the drains are considered, their obstructed state, the very little fall there is, &c., &c., and the height of their cills, it is quite clear that more water-way is required to carry off the water from the surface of those Fens in due time, than they possess.

As to the last,—The water which falls on the high lands skirting the Fens comes down very rapidly, from the great declivity of it in many parts, and there are many small brooks where large quantities of water are collected, which fill their channels and flood the adjoining lands, and being at a great distance from the outfalls, lie on the surface for weeks together, and do great injury.

From the description I have given of the injury to which the extensive districts of low lands contained in the great Level of the Fens are subject, it is quite evident a better mode of drainage is imperiously required: I shall now therefore proceed to lay down a plan, which I trust will be found capable, if carried into execution, of affording a remedy to all the imperfections I have enumerated, i.e., that it will effectually drain the South and Middle Levels of the Fens, prevent the lands from being inundated, and improve the harbour of Lynn, and the navigation of the rivers and lodes which pass through the said Fens.

I propose first,—That the Eau Brink cut shall be made in the line, and of the full dimensions as settled by the deed poll of Captain Huddart. That its bottom opposite Standringham Eau shall be of the depth mentioned in the tables annexed to the said deed poll; namely, about 9 feet 6 inches under the level of the cill of Denver sluice.

Second,—That the Old Ouse shall be straightened, deepened, and widened, where wanted, from Eau Brink to Denver sluice, diminishing about 10 feet in width, and the bend above Magdalen bridge to be cut off, which will shorten it about half a mile.

Third,—That a new cut shall be made up the wash way from near Denver, to the bend at Mepal, and from thence to Earith, the old river shall be scoured out, deepened, and enlarged, where wanted; the bottom of the river at Earith to be 60 feet wide, and 4 feet above the cill of Denver Sluice; this will give a regular fall in the bottom to Lynn, of 4 5-6th inches per mile. The bottom of the river, next to Denver, to be 65 feet wide. The cut being 6¼ feet deep at Earith, and 8 feet at Welmore Lake, and the slopes three horizontal to one perpendicular, it will be about 100 feet wide at the former place, and 113 feet at the latter.

I have preferred the making of a new cut up the great wash-way between the New Bedford bank and the Old, because the east, or New Bedford bank, lies so near to the river, that there is not sufficient room for the slope, it being in many places undercut by the water, and therefore to give it the necessary slope, a part of the New Bedford river must be filled up, or the bank removed further from it, the expense of which would be nearly as great as a new river; besides, to give the old river the necessary dimensions, it must either be turned into some other course, while the work is in hand, or it must be deepened by a mud machine, which would be equally expensive, whereas, if an entire new cut is made from Mepal to Denver, the whole work can be done, except the upper part, without disturbing the course of the river, until it is completed, and the part above Mepal not requiring any great enlargement, it can be ballasted out to the proper size.

By the above plan, the earth which comes out of the new cut will form strong and substantial banks on each side, and which, with proper foreshores, will render the Old and New Bedford banks unnecessary, and by doing away the extensive wash, many thousand acres of land, which are frequently drowned, will be rendered of great value.

Fourth,—The Old Ouse and Grant are in some places of a sufficient capacity, but they are very crooked, and full of shoals, and so are the Stoke, Brand, and Lark or Mildenhall rivers, and they are not completely, but only partially embanked. I therefore propose, that the Old Ouse and Grant shall be scoured out, deepened, straightened, and embanked, where necessary; and the bottom at Denver sluice to be 60 feet wide, with similar slopes to the New Bedford river. I propose to avoid the bend at Prickwillow, by a straight cut from the lower end of Sasse Fen to Ely, and the Mildenhall or Lark river to

be brought to it, by a new cut, from the bend above Prickwillow across Burnt Fen, to near Littleport.

This new cut in the Old Ouse will shorten the distance from Denver to Clayhithe to about 26 miles, it being now 29¼ miles, and the rise from the cill of Denver sluice to the cill of Clayhithe lock, being about 9 feet 6 inches. If the bottom of the river at Clayhithe is sunk to 3 feet under the cill of the lock, there will be a fall in the said bottom, to Denver sluice, of 3 inches in a mile; but if the cill of Denver sluice were to be lowered to the intended bottom of the Ouse, there would be an additional fall of 4 feet 2 inches, which would give a regular fall in the bottom of this river of about 5 inches in a mile. A question, however, will here arise, namely, whether Denver sluice should be taken down, and a new one rebuilt on a better construction, with its cill of the proper depth, or, whether it should be entirely removed; either plan will answer the purpose; but if the rivers are made of sufficient capacity, and the banks of the Ouse and Grant are made of a sufficient height and strength, as also those of the Stoke, Brand, and Mildenhall rivers, there can be no danger of taking down the sluice entirely, by which the tide will be admitted up these rivers, and thereby greatly improve the harbour of Lynn, and the whole of the river to Denver sluice, and for a considerable distance above it; but in this case some provision must be made for the preservation of the navigation in these rivers.

The capacity I propose to give to these respective rivers is calculated according to the dimensions which have been settled for the Eau Brink Cut, and whose dimensions are adequate to the drainage of the quantity of land, which, as far as I have been able to ascertain, send their waters into the rivers Ouse, Grant, &c. This quantity amounts to about *Two Millions of Acres*.

The declivity which is proposed to be given to the beds of the rivers, and the improved outfall at Lynn, will lower the surface of the water at Eau Brink at least 5 feet, and it will also be proportionably lowered at Denver, and up the other rivers. This will give so much additional fall to all the drains which pass through the low lands, and thereby render the drainage perfect, if executed according to the following plan.

The first object to be accomplished in the drainage of a low district of land is to intercept the water which comes down from the high lands. For this purpose a catch-water drain is proposed to be made round the whole extent of the Fen: that for the Middle Level to commence at or near Monks-wood, and to decline at the rate of 6 inches in a mile to the river Nene, at Standground Sluice, terminating at a level of 6 inches below the cill. Another catch-water drain is proposed to commence at or near Monks-wood, and to decline at the rate of 6 inches in a mile to Earith, where it will join the Great Ouse at the height of 10 feet above the cill of Denver sluice. This drain is laid higher than the former, on account of the height of the land through which it will pass, and it cannot well be laid lower at a moderate expense, unless it were to skirt the Fen; and if so done its length would be nearly doubled, and a sufficient fall to carry off the water could not be conveniently obtained.

The South Level is likewise proposed to be surrounded by catch-water drains, one to commence near Clayhithe, in some high ground in the parish of Waterbeach, to skirt the Fen with a declination or fall of 6 inches in a mile, and to end in the Ouse, near Hermitage sluice, at the height of 7 feet above the cill of Denver sluice.

Another catch-water drain is proposed to commence near Quy Mill, and to skirt the high lands of Swaffham, Reach, Burwell, Fordham, Freckingham, and Worlington, and to cross the Mildenhall River at West Row Ferry, by means of an aqueduct, the level being sufficiently high to allow the floods to pass. From this place it will skirt the high lands of Holywell Row, Eriswell, and Wangford, to the Brand River, near Wilton Ferry, and cross that river by an aqueduct; from thence it will skirt the high grounds of Wilton, Feltwell, and Methwold, to the Stoke River, which it will cross about a mile below the town. Here the river must be lowered, to give room for an aqueduct, after the passing of which it will skirt the high lands of Stoke, Roxham, &c., and pass through Fordham to the Ouse, below Denver Sluice.

A catch-water drain, taken in the line I have described, and without joining any of the rivers which pass through the southern district of the Middle Level, would be the completest thing that could be made in the way of a catch-water drain. Its fall is intended to be four inches in a mile, which would admit of its being easily made navigable, and communications might be made with the different rivers, lodes, and navigable drains in the Fen, by means of locks, and fresh water could be dispersed for the use of cattle and stock over the whole Fen, without injury to the navigation, which, by the increased depth of the rivers, would not then be in danger of wanting water; and in floods a part of the surplus water might be carried into the Ouse, below Denver, and so prevent, in some degree, the pressure of water against the banks of the Old Ouse, the Stoke, Brand, and Mildenhall rivers, &c. &c.

The objections to the catch-water drain I have described are its great expence, in consequence of all the navigable lodes and rivers requiring to be crossed by aqueducts, and to obtain the necessary height some heavy pieces of cutting and embanking would be required. It therefore becomes a question, whether it would not be better to make the catch-water drain in separate lengths, each length terminating in the respective rivers, in place of crossing them by aqueducts, and if this plan were to be adopted, that part of it lying between the Stoke river and Ouse at Denver might be saved. The high-land water to be intercepted by it being less than any of the others, all the aqueducts and expensive pieces of embankment would also be saved, (without preventing it from being made navigable,) which together would amount to a large sum; and part of this money might be applied, either to the strengthening of the embankments of the rivers, lodes, and brooks in the South Level, or to the improvement of the interior drains, as should be judged most useful.

By means of the catch-water drains I have described, all water would be prevented from getting into the Fen except what falls on its surface and on the surface of such high pieces of ground as are within the precincts of these drains, such as the high lands in the Isle of Ely, in Soham, Wickin, Southery, &c., and these high lands I propose to be surrounded with small catch-water drains, to discharge the water into the respective rivers. It now only remains to describe the plan I have devised for carrying off the downfall water.

I have said before, that by means of the Eau Brink cut and the improvement of the river Ouse and Hundred Feet the surface of the water at Eau Brink will be lowered at least 5 feet. I therefore propose that the drains for the downfall water of the Middle and South Levels shall terminate in the Ouse near to the head of the Eau Brink cut, which will give them so much additional fall, and will be sufficient to effect the complete drainage of these levels, without the assistance of windmills.

For the Middle Level, I propose that a sluice of 50 feet water-way shall be placed near to the head of Eau Brink cut, on the west side of the river, and from thence a new drain to be made in a straight line to the Old Bedford river, opposite Denver sluice, of 50 feet bottom. This drain will cross in its course the Tongs drain, Salters lode, and the Old Bedford river. The Tongs drain may then be filled up, as well as that part of Salters lode and the Old Bedford river which lies between this drain and the Ouse.

Second.—That Popham's Eau shall be scoured out, deepened, and enlarged from its junction with this new drain to its junction with the Old Nene, near Well Common, and the Old Nene, from thence to its junction with Wittlesea dyke; and again, this dyke to be scoured out, deepened, and enlarged, to Standground sluice. I must here remark, that the Old Nene is very crooked, and the expence of making it of sufficient capacity to receive the water which will drain through it will be very great. It would, therefore, be better to make a new cut from Popham's Eau, at the place where it is joined by Thurlow's drain, to Whittlesea Mere. This would shorten the distance very much, and if the bottom of the drain at this place is laid 4 feet under the surface of the ground, there would be a fall in the said bottom of 4 inches in a mile. But if this drain is not made, Bevil's Leam, between Whittlesea Mere and Whittlesea dyke, will require to be scoured out, deepened, and enlarged; and likewise the Old Nene, through Ramsey Mere and Ugg Mere to Whittlesea Mere.

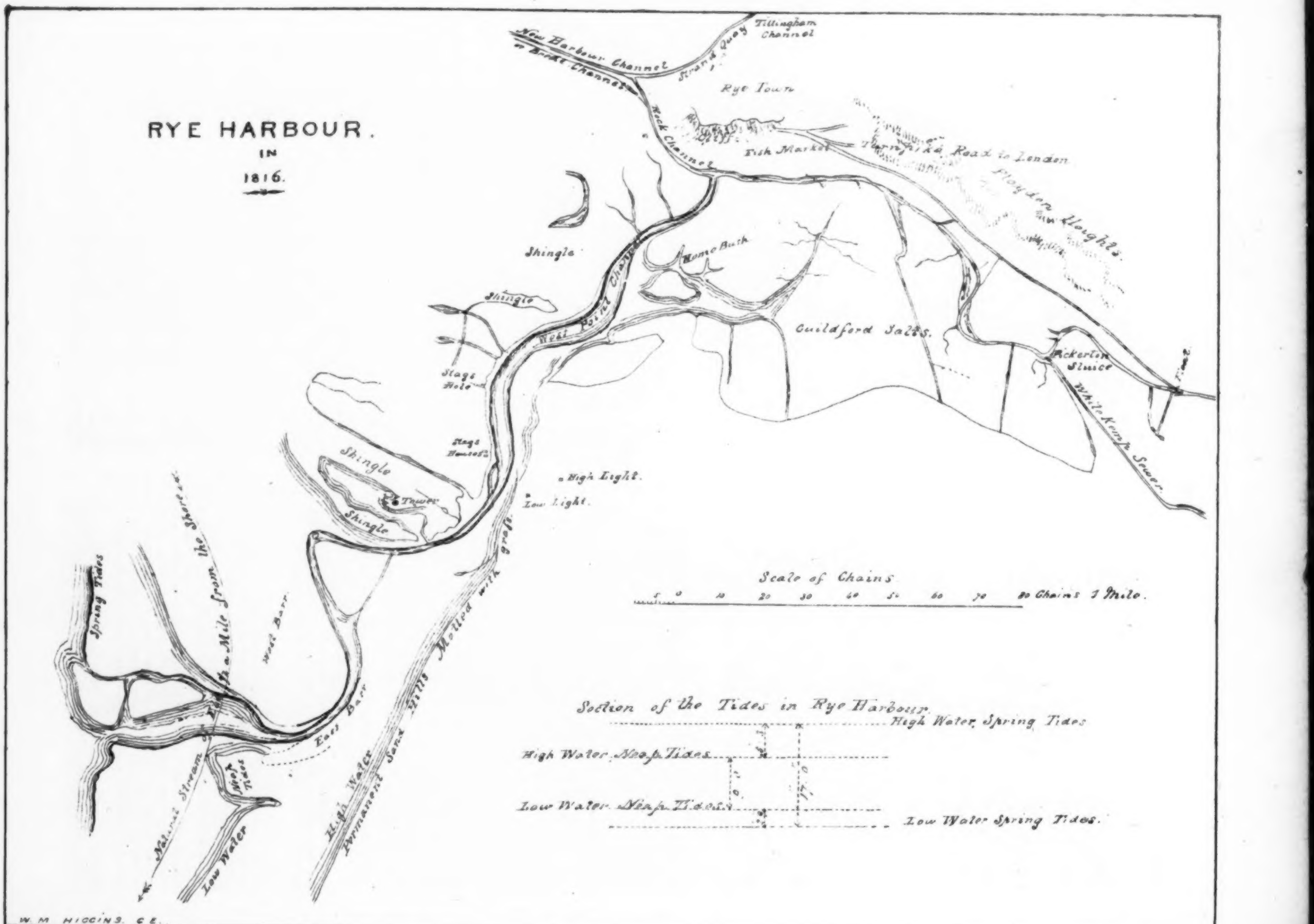
Third.—That Thurlow's, or the 16 Feet drain, shall be scoured out, deepened and enlarged, from its junction with Popham's Eau to Vermuyden's or the 40 Feet drain.

Fourth.—That the Old Bedford river, from the head of the new proposed drain opposite Denver sluice to Earith, shall be scoured out, deepened, and enlarged, as well as Vermuyden's, or the 40 Feet drain.

In respect to the South Level, I propose, first—That a sluice of 70 feet water-way shall be placed at the head of the Eau Brink cut on the east side of the river, and that from this sluice a new drain of 70 feet wide at bottom shall be made in a straight line to St. John's Eau, near Stowe bridge, and from thence to Denver the said Eau shall be scoured out, deepened, and enlarged to the same size as this new proposed drain.

Second.—That from the head of St. John's Eau a new drain shall be made in a straight line to the drain of Grunty Fen, at Littleport Mow Fen, and passing under the Old Ouse above Denver sluice by means of a cast-iron aqueduct. From the junction of these two drains, that to Grunty Fen must be scoured out, deepened, and enlarged.

Third.—That from the head of St. John's Eau another drain shall be made to the extremity of the Level near Clayhithe, passing under


RYE HARBOUR.
IN
1816.
New Harbour Channel
or Brede Channel
Strand Quay
Tillingham Channel
Rye Town
Rock Channel
Fish Market
Turnpike Road to London
Playden Heights
Shingle
Home Bush
West Point Channel
Guildford Salts
Stage Hole
Stage Houses
Shingle
Tower
Shingle
High Light
Low Light
Ickerton Sluice
White Kemp Sewer
Scale of Chains
5 0 10 20 30 40 50 60 70 80 Chains 1 Mile.
Section of the Tides in Rye Harbour.
High Water Spring Tides
High Water Neap Tides
Low Water Neap Tides
Low Water Spring Tides.
Spring Tides
West Barr
East Barr
Neap Tides
Low Water
High Water
Permanent Sand Hills Motted with grass
W. M. HIGGINS. C.E.

the Steke Brandon and Mildenhall rivers, and under the Soham, Reach, Burwell, Swaffham, and Bottisham lodes, by means of cast-iron aqueducts. This drain will skirt the high lands of Southery, and from thence will run in a straight line across Burnt Fen to the drain in Ely Fen, and pass through that drain to Barway and through Forday to the high lands of Wicken, and skirting these high lands, and passing through Swaffham and Battisham high Fens to its termination. If this drain at its head is sunk to the depth of four feet under the surface, it will have a regular fall in its bottom of three inches and a half in a mile.

It will be joined in its course by the Southery Fen drain, or Dr. Sam's cut, by the Stoke lode, Mildenhall Sedge Fen drain, and by all the drains and droves in those parts of the South Level through which it passes, and all of which must be scoured and cleansed so as to convey to it the water of the respective districts through which it passes.

Fourth.—That the Old West river shall be scoured out, for the purpose of carrying off the downfall water of the lower lands lying between the Isle of Ely and the catch-water drain from the Hermitage to Waterbeach, and that the water of this drain shall be carried under the Grant at the head of Hall Fen, to join the drain on the east side of the river.

The drains proposed in the foregoing scheme will be found fully adequate to the draining of the South and Middle Levels, as principal drains, but there are many works of a lesser kind which will require to be done to render the whole complete, but these could not be enumerated in the present Report without extending it very much, and without a minuteness of inquiry inconsistent with the outline of a general scheme;—I trust, however, I have made such allowances in the annexed estimate, amounting to £1,188,189, as will cover the expence of all these lesser works.

The sum of money to which this estimate amounts is, no doubt, very large; but, on the other hand, the extent of land to be drained amounting to more than 250,000 acres of low land cannot be accomplished without works of great extent and magnitude. Probably a cheaper mode of executing them may be devised, such as deepening the rivers by the spade machine, but if this mode were to be resorted to, the quantity of mud which would be sent down the rivers while the works were in hand, would be very prejudicial to the harbour of Lynn, as some of the hardest of it would be apt to settle and obstruct the entrance; and it appears to me, nothing could justify such a mode of proceeding. But by the mode I propose, no injury whatsoever can be done to that harbour; on the contrary, it will be greatly improved. My aim throughout the whole has been to lay down such a scheme as would effectually drain these Levels, and prevent the rivers from inundating them, and greatly improve the navigation; and I cannot entertain a doubt, if they are carried into execution in a judicious manner, the extensive interests connected with these Fens will be most essentially benefited; and, large as the estimate is, it will not on the average exceed £5 per acre, if even the whole were to be laid on the land, but the navigation should bear its share; a very moderate sum, in my mind, for the benefits of a perfect drainage. Some lands probably could not bear so large a tax, but others would bear a much larger sum; and it will be the business of those to whom the plan for raising the money requisite for the works (should this scheme be carried into execution) to apportion the expence, in an equitable manner, both on the lands and navigation.

JOHN RENNIE.

London, August 7th, 1810.

MR. CUBITT'S REPORTS ON RYE HARBOUR.

First Report.

TO THE COMMITTEE OF THE COMMISSIONERS FOR THE IMPROVEMENT OF RYE HARBOUR.

GENTLEMEN,

In pursuance of instructions from the chairman of the Commissioners, and in conformity with resolutions passed at a meeting held on the 2nd instant, I have taken a view of the river and harbour from Scot's Float Sluice to the sea, and from Tillingham and Bridgepoint Sluice to the fish market, together with the saltings or tide marshes, as proposed to be embanked off on both sides of the river respectively.

I therefore beg to submit to the consideration of the committee this my Report as to the state of the harbour, &c., and the mode I would recommend for the improvement thereof, under the provisions of the new Act of Parliament; first stating what I understand to be the probable available means, at the disposal of the Commissioners, for improving and keeping up the harbour; and which, from the best information I can obtain, are not likely to be much over £1000 or £1100 per annum (after deducting the usual salaries, &c.), besides the balance (if any) that may arise from the improved value of the marshes, embanked off from the tides, after defraying the cost of properly embanking and draining the same.

With such limited means, the Commissioners must not expect that any grand plan of improvements can be laid down, which would afford immediate relief; or that art, even with the largest sums of money that could be raised upon such means, can in one, two, or three years, restore the deep water, and straight entrance, that nature has been two or three centuries filling up and deteriorating; still by laying down a plain, simple, and economical plan, and acting upon it *steadily* and *perseveringly*, I have not the smallest doubt that the harbour may be made gradually and continually to improve, from after the first season; so as eventually to obtain a regular channel, and a depth of water up to the fish-market, and quays, within one or two feet of what it is at the entrance of the harbour, just below the pier head; and also that considerable improvement may be obtained in the outfall channel, across the sands of the bay, into the deep water of the British Channel.

Without going into a long history or detail of causes and effects, relative to the silting up of the harbour, or the deterioration of the entrance, which, although they might probably be accounted for satisfactorily, would answer but little purpose in the present state of things; I shall proceed at once to the objects contemplated by the Act of Parliament, viz., the embanking the marshes, and the improvement of the navigation.

The first step I would advise the committee to take, is to have a careful and correct survey made, and laid down upon a large scale, of all the lands and works under the jurisdiction of the Harbour Commissioners, the salt marshes inclusive, from Scot's Float Sluice down to the sea; showing the exact form of the river channel, both at high and low-water; as well as the form, dimensions, and position of the present works at the harbour entrance; together with the exact situation of the present channel, and low-water lines, down to the sea: such a map as this, on a scale not greater than 100 or less than 200 feet to the inch, well mounted on canvass, would be a most useful, and sometime hence, almost an invaluable document to the Commissioners, to refer to as to the form of the river, and state of the entrance at the present time; and without some plan of the kind it will be almost impossible for myself or any other engineer to lay down the requisite improvements, and describe the various works from time to time, in an intelligible manner; and I have therefore no hesitation in most strongly urging the committee to take immediate steps for obtaining this survey; any information relative to which, I shall be most ready at all times to afford.

The embankments to the marsh-lands will of course claim the first attention of the Commissioners, (and in fact I find a portion of that work already begun under the superintendence of Mr. Elliot,) so as to secure by a short length of embankment from Scot's Float Sluice to the Union Sluice, all the marsh-lands comprised in Nos. 1, 2, 3, 4, 5, and 6, which I think a very eligible measure.

I observe by the Act of Parliament, that these marsh-lands are to be inclosed to the satisfaction of certain gentlemen named in the Act; and am therefore doubtful whether I ought to concern myself about the embankments; but as much that concerns the harbour improvement is particularly connected with the situation, at least, of the embankments, I deem it my duty as an engineer to advise you, that the line of them requires to be very carefully considered as connected with the future improvement of the river channel; and that the top of the new banks should be at least one foot higher than the mark of the highest tide on record, and be perfectly level; the top to be four feet wide, with a batter or slope of one horizontal to one perpendicular on the side next the marshes; and of two horizontal to one perpendicular on the side next the river; and if the faces be dressed about two or three inches hollowing, so much the better.

In setting about the improvements of the river, it will be best, and in the end cheapest, to do that first which will be a permanent advantage, and this I take to be the improvement of the channel between Scot's Float Sluice and the fish-market, by making a new cut through the marsh No. 9 on the map, and taking off the great bend into which the Union Sluice discharges. This improvement, if quickly and properly carried into effect, would act beneficially not only on the river channel, as connected with the harbour, but also on all the lands

drained by Scot's Float Sluice, and the Union Sluice also; the waters from which should of course be taken in a proper direction into the new cut; the making of which should be immediately followed by improving the low-water channel of the river, in a line to be laid down on the large map; toward which a good deal may be done by hand labour: but to make the harbour what it can and ought to be made, recourse must be had to a steam dredging engine, which would in a very short time bring up a good uniform low-water channel from the harbour's mouth to the quays and sluices respectively; and in proportion as the low water channel is deepened and straightened, so in proportion will be the quantity of water taken in by the sluices, and good effect of the back water and freshes let out by them upon the bottom of the harbour's entrance.

The state of the channel from the fish-market downwards is very bad. In many places the flood and ebb tides are making separate channels, and the latter, from running so much longer at the lowest state of the tides, undermine the foot of the banks in the great bends, and let down the lands at a surprising rate; as may be particularly seen at Stag's hole, the low-water current from which sets directly upon the eastern wicker-work bank, and tends to undermine and destroy it very fast; now this might be in a great degree remedied by deepening a channel, which appears to have been judiciously begun, and called, as I am told, the *Dandy Channel; if this channel were deepened down to, or a little below, low-water, close round the point, and the present one above Stag's-hole stopped off by a low dam of stakes, stones, and faggots, just below the Holm-bush, so as to turn the stream of the freshes through the Dandy Channel*, the navigation and set of the current out past the pier would be very much improved. I should also recommend that the channel opposite the pier-head be cleared of the present irregular masses of gravel, &c., in something like a regular form, so as to give the water a proper course at a uniform distance from the pier and wicker-banks; all which might soon be improved by the constant judiciously-applied labour of a very few hands.

As regards the works at the mouth of the harbour, of a more extensive kind, I should advise but little to be done till I have a good map to consider and lay down the lines upon; but there is one thing which I think should be done at once, which is, the repairing and making good the large gap in the eastern work, or wicker-bank, just above the pier; and which in its present state, and from the height of the sand bank at the back, is in my judgment productive of injury to the harbour: it should be well secured with close piling at the foot, and brought up in the same form and in the same manner as the present work, to which it should be well joined in at both ends; I would also recommend that the south end of the western groin or jettee be repaired and land-tied, and that the last or low length be brought up to its proper height and completed; but that no more be done till I can have a map with the present works laid down, on which to consider the future, for so conflicting are the opinions with respect to whether eastern or whether western works be best, and so altered (in my opinion) are the circumstances of the case within the last six or seven years by the coming down of the great Full, which is now approached sufficiently near to influence (by the current which sets in and out of the large reservoir which it encloses) the sand bar which was formed opposite the channel, and made the entrance very crooked and difficult to navigate; I shall therefore defer till a future opportunity any further observations as to eastern or western works; and when I get a map of the *locus in quo* and a little acquaintance with the place, shall most probably draw up a Report expressly on the subject.

From the above observations the committee will be enabled to perceive that my views brought into an abstract form are as follows:—

First. That a good map, on a large scale, be made of the harbour forthwith.

Second. That the present embankments in hand be completed, but that none be begun below the town till the situation of them can be laid down upon a map as considered with regard to the future channel and the river.

Third. That means be considered for making a new cut for the river across No. 9.

Fourth. That the low-water channel of the river be improved below the Holm bush, by opening the Dandy Channel and clearing the channel of gravel banks.

Fifth. That the gap in the east-work be made good,—and

Sixth. That the last length of the western groin be completed.

I am also of opinion, that in order to go on with the works in the best and most economical manner possible, it would be well for the Committee to inform themselves as to the estimate and extra expense to which they must necessarily be subject during the first few years of carrying the Act of Parliament into effect, so that, if requisite, the arrangements might be made for taking up just so much money as would put them in possession of sufficient engines, barges, and implements, the use of which would be far more available to the Commissioners, than the annual interest of their first cost.

Should there be any points on which the Committee wish for information, omitted in the above, I trust they will do me the favour to command it, and with a wish to lend every assistance in my power towards the improvement of the harbour,

I have the honour to be, Gentlemen,
Your obliged and respectful servant,
W. CUBITT.

London, July 29th, 1833.

Second Report.

TO THE COMMISSIONERS, &c.

Having been called upon by letters from Mr. Manser of the 28th of January last, and subsequently, to inspect the harbour of Rye, with a view to my reporting upon the works that may be required for its improvement, I have now the honour to submit to the Commissioners this Report upon the subject; premising that I went down to Rye on Thursday last, the 11th instant, and devoted the two following days to a survey or inspection of the harbour and works, and making such examinations and inquiries relative thereto, as I deemed necessary to the execution of the duty required of me.

Adverting to my former Report of July, 1833, it will be seen that I then recommended certain works to be done within the harbour, that is, above the entrance at the old pier head; such as straightening and deepening the river's course, taking off bends, diverting the flood and ebb streams into a uniform channel, &c.; together with some slight works of reparation at the harbour entrance, both on the eastern and western sides thereof:—but leaving the great question of permanent works between the harbour entrance at the pier and the low-water mark at sea, until some future opportunity, after the works of embankment, &c., under the then new Act of Parliament, should have been completed.

Since that time, however, little or nothing appears to have been done towards deepening, altering, or improving the river channel, which remains very nearly in the same state it was six years ago, except being a little worse; but the circumstances at the mouth of the harbour are very much changed since that time; the whole of the piling or groyne works are removed, and the mass of beach or shingle which was accumulated behind them is gone; a considerable length of a rubble stone pier or breakwater has been erected, from the old pier head in a direction south-half-east to the extent of 1500 feet, at a height of 10 feet above low water; so that on the whole, the harbour entrance is certainly improved in appearance, and is in my judgment certainly better than it was in 1833, but whether this improvement be wholly owing to the eastern works which have been erected, or whether other circumstances may not have contributed to its improvement, is a matter of doubt, inasmuch as it appears that during the interval, about 400 acres of land within the Fulls have been embanked off from the tides, and thereby lessened the indraught and range of the surf at high and raging tides, which had a great tendency to bring shingle to, and even into the mouth of the harbour; it is my opinion that this circumstance has had its due share in the improvement of the harbour, and that good would arise if the tides could at any reasonable expense be kept entirely out of the main Fulls.

As regards the main question which has so long agitated the minds of many persons interested in the improvement of this harbour, and in either case as I believe with an equally sincere wish for its improvement, by those who advocated either of the methods proposed, viz. whether eastern or western works were best as a general principle of improvement to the harbour? I can state this much, that in my judgment the harbour may be improved, and a straight channel formed and maintained from the pier head across the sands to the sea, by means of either eastern or western works, with different degrees of efficiency and different amounts of cost; but as one method has been already adopted and carried out to some extent, and with apparently good effects, I have no hesitation in strongly recommending that the

continuation of the east stone breakwater be steadily and constantly persevered with in short lengths, so as to give time for the current to excavate the foundations, in turning round its end to the eastward, as the work proceeds, and that it be carried on at its present height, till such time as the low-water channel will take a straight course into the sea in the same direction as the breakwater, and which in my opinion will not be till the end of the breakwater comes as near the sea line of low water as the last bend of the channel is, where the stream takes a southerly course into the sea. What this absolute distance may be, I am unable to state (from there being no survey or plan of this harbour in possession of the Commissioners, a deficiency which I did hope, from the strong representation relative thereto made in my former Report, would have been obviated before this time), but which distance I imagine may be about 3000 to 4000 feet from the present end of the breakwater.

Now taking the part already done to be about 1200 feet of efficient breakwater, at a cost of £3,100, it would, by the rule of proportion, cost £10,333, in the nearest round number, to complete 4000 feet; and which, at an expenditure of £1000 per annum, would complete the work to that extent in the 11th year from the time of its commencement, or in other words £1000 per annum would serve to add about 388 feet yearly to the breakwater, more or less, according to circumstances.

I mention the sum of £1000 per annum, from having understood that about that sum will probably be available for harbour improvements, after defraying current expenses; but that, or even a smaller sum, uniformly and properly expended, will, at no distant date, prove the utility and efficiency of an eastern breakwater, for preserving a direct low-water entrance channel across the sands of Rye Bay to the harbour, so that the latter may be accessible from the sea during the night, by a single pair of leading lights.

With regard to other and minor improvements in the harbour, its channels, quays, &c., many might be suggested, but without a plan to lay them down upon, it is almost useless to enter upon the subject, inasmuch as no written directions for works of this kind, without a plan, can be understood in their details. I can only, therefore, recommend generally, that if the means offer an opportunity, it would be advisable to deepen the Dandy Channel to the level of low water, and then stop the channel by Stag's Hole, at or near its upper end, by which means the ebb stream (as well as the flood), would take that course, and the navigation be very much improved; besides which, a more effectual scour would obtain, and any accumulation of beach be prevented at the mouth of and inside the harbour.

Many other improvements might also be gradually made in the river channel, both at and below the town, particularly in the very inconvenient bend near Brede Sluice, and again at the mouth of the old river channel below, all which should be marked down with definite lines and dimensions, on a good plan, and could then at any future time be gradually carried out, as the wants and means of the harbour might require or afford.

Having thus touched upon the principal points connected with the improvement of this port, I may perhaps be allowed, in connection therewith, to make a few observations as to the best mode of carrying such improvements into effect.

Hitherto it has been the custom (as I am given to understand) for individual Commissioners or members of a committee to undertake the direction and management of the harbour works, or certain portions thereof, according to his or their notions; sometimes by erecting works west of the harbour entrance, and sometimes east, as the case might be.

Now this mode of proceeding is in my judgment extremely reprehensible; it is unbusinesslike, it tends to promote animosities between individual members of the commission, who may each be actuated by equally praiseworthy and honest motives in advocating his favourite plan; it tends also to the waste and misapplication of funds, without fixing any proper responsibility, and is moreover below the dignity of such an important commission, to have their works carried on in such an unusual manner.

I therefore take the liberty of most strongly recommending the Commissioners, as a first and most effectual step to their improvement, to have the whole of the executive part of their proceedings put upon a better system, by laying down a fixed plan of improvements, and appointing a responsible officer as resident engineer (or expenditor, as I believe the local term is), to see to carrying the harbour works of all kinds into effect, who should receive his instruction from, and be accountable to, the body of Commissioners only, or a committee of works to be by them appointed, and over whom no individual Commissioner should have any control, or of the works under his charge; by pursuing such a plan as this, under proper rules and regulations, I have no doubt unanimity would prevail, money be saved, the improvements be expedited, and the town and port of Rye, together with the sewage draining out through the same, be all greatly benefitted; and also, that within the short space of from seven to ten years, there may be a direct channel from the sea into Rye harbour, and a very much improved navigation up to the quays and town of Rye.

W. CUBITT.

London, April 17th, 1839.

INSTRUCTIONS FOR THE USE OF THE MARINE ENGINEER'S LOG.

BY S. CLEGG, JUN., ESQ., C.E.

[We have been favoured by Mr. Clegg with a manuscript copy of his Marine Engineer's Log, which is an important and almost invaluable contribution to the progress of steam navigation. The log now in use on board the West India Mail Packet Company ships, and in many other sea vessels, is a most clumsy perfomance, whoever may have been the author.* A well-arranged log, properly kept, is not a useless document when the vessel has performed her voyage; but in the hands of the engine-builder furnishes data for calculations and improvements, the importance of which can only be known to those who are intimately acquainted with all the varieties of construction in the marine engine. It may in fact be considered a record of experiments, judiciously arranged and continued without interruption. But whatever may be the care and industry with which experiments are performed, they are useless if the proper observations be not made, and almost so if not properly arranged. Mr. Clegg's log secures both these indispensable objects, and we therefore hope that it will soon be universally adopted.—ED.]

The log book of the engineer is intended not only to give information respecting the ship for which it is kept, but to furnish practical data and proofs, by reference to which a guide may be obtained, for those engaged in the manufacture of the machinery or the general advancement of steam navigation. Therefore all circumstances which in the opinion of the engineer will tend towards this object, must be carefully noted down; all defects in the boilers or engines, as soon as they are perceived, and accidents or failures, their causes, and the means employed to repair them, or guard against their recurrence, given at length.

The expenditure of stores must be noticed in the log as well as in the store-keeper's day book. And those required to complete for sea be put down at once, that they may not be forgotten when the demands are made out at the end of the voyage. A column in the day book headed "demands" is left for this purpose.

Height of Steam Gauge.—Before the fires are lighted, see that the top of the indicator stick corresponds with the mark zero on the scale. Keep the steam rather *below* than *above* the pressure on the safety valve. Mark in the log the *mean* height of the stick.

Degree of Expansion.—Every possible attention must be paid to the expansion, and no change of wind or weather must pass unnoticed. When the ship is deeply immersed, the quantity of steam admitted upon the piston must depend upon the state of the condenser barometer; but if the slide itself cuts off at three-fourths of the stroke, the expansion may be generally thrown off. If the ship, however, be influenced by canvass, steam may be cut off until the number of revolutions of the paddle-wheels correspond to those found in practice to be, when the ship is under steam alone.

The senior engineer must use his judgment in applying the expan-

* Believed to be Messrs. Chappell and Mills.

sion, taking care to use the *highest possible* grade consistent with the proper speed of the ship. But during favourable winds he must be more especially attentive, increasing or decreasing his steam as canvas is taken in or set. The use of expansion, although coming into use more generally, is not sufficiently appreciated by the commanders of steam ships, and it is to be regretted that they often exert unnecessary influence over the engineer, who on such occasions must of course obey *first*, but should respectfully point out any error in the command *afterwards*.

Number of Revolutions.—If a counter be attached to the engine, the number marked on at the end of the watch divided by 240 will give the number per minute, but the difference of time must be added or subtracted each day at noon when the observation is taken. The total number of revolutions by counter must be put down every day at noon.

The ratio existing between the speed of the wheel and the ship should be noticed now and then during the voyage.

Coal consumed during Watch.—The quantity is best ascertained by tallying the number of baskets of known weight that are used every watch; with this charge the coal trimmers may be entrusted—place down more rather than less for the expenditure, and for this purpose remaining pounds may be noticed as qrs.

A good deal might be said about the mode of firing, but at the end, the engineer would find his own experience to be his best guide; attention and caution in others must be enforced by him, and his directions carried out to the letter. Welsh coal, such as Tredegar, Risca, &c., is now coming extensively into use, and a quiet fire about 8 inches thick is the best, if the the furnace be of good width. In feeding, the fires should be raked back and the fresh coal thrown on in the front, so that the smoke may be consumed by passing over the heated fuel. With Newcastle coal a thinner fire may be used. But thick and thin fires are relative terms. Too thick a fire suffers many of the effective gases to pass through the flues unconsumed, and too thin a fire allows too much air to pass through them—both attended with waste of fuel. No coal must be suffered to remain on the plates larger in size than a man's fist, and the trimmers must be directed to reduce all lumps ready for the firemen.

The bunker doors, &c., must be locked; not that the firemen may be stinted in the use of the coal, for it is to be presumed the engineer on watch will not suffer waste; but that the coal may be taken from the proper place, and the senior engineer may know the times that each bunker has been worked from. It is of course necessary for the proper trim of the ship that the coal be worked with reference to it, and therefore a secured door renders any mistake impossible.

The cubic capacity of the bunkers and holds wherein coal may be stowed, must be accurately determined, allowing 48 cubic feet to one ton, and the quantity expended be checked by the calculated remains.

In coaling the ship, one trimmer must keep a tally as a check against the quantity said to have been supplied, and return it to the senior engineer, who will make a note accordingly every day at noon. If the coal be put on board in baskets or sacks, seven of them at least must be measured or weighed every day, in the presence of the foremen of the wharf, &c.

In stowing coal for long voyages, or in any case where the ship has to be filled up, too much care (especially at the commencement of the work), cannot be taken, and an engineer must be always on watch, the senior engineer himself going into the bunkers and holds every now and then, to be satisfied that the stowage is properly done.

Height of Condenser Barometer.—The mercury ought to stand at an average height of 28 inches, with the injection water at 60 degrees of Fahrenheit. In perfect order the vacuum will perhaps stand at 29; but it ought not be suffered to fall below 27, unless there is an apparent cause, such as may happen from the heat of the sea water in tropical climates, or from accident.

Injection in Square Inches.—If the valve be not marked, the engineer should do it himself, as by knowing the exact quantity of water admitted into the condenser, and the temperature, very useful results may be obtained. These ought always to correspond with the degree of exhaustion.

The Boilers.—Specific gravity of the Brine.—Hydrometers for testing the density of the water in the boilers are graduated so that the line of flotation in river water is zero, and in sea water 10, at a temperature of 60° Fahrenheit.

The brine and feed pumps, must be regulated so that the density is kept considerably below that point at which salt would be deposited, viz., at the mark 20 on the hydrometer. The average density, without "blowing out," may be 15; but by discharging about 5 or 6 inches in depth of water every third watch, or at midnight and noon, the water may be kept lower. But every watch the specific gravity of the water in the boilers must be tested by the hydrometer, and if it be found too high the feed must be gently increased, the water suffered to rise 5 or 6 inches above its ordinary level in the boilers, and then "blown out;" and this process must be repeated as often as it be found requisite, and each boiler treated independently and as if it were by itself, the spesific gravity and the depth of water in inches blown out being marked in the log opposite the proper hour.

These directions are presuming that brine pumps are attached to the boilers. If, however, there be no such apparatus, the water must be kept at its proper density entirely by "blowing out," and this operation becomes of the first importance. The hydrometer is to be used at intervals of two hours, and the state of the brine in each boiler noted down separately, with the quantity or depth of water blown out.

The difference which will be found in the specific gravities at these intervals, is accounted for by the different rates of evaporation, and the quantity of water withdrawn will be in proportion to its saltness. To blow out more water than necessary, is attended with a waste of fuel, and on the contrary, if too little be blown out, all the bad effects of deposition will ensue.

Every opportunity must be taken to blow the water *entirely* out of the boilers; and if there be time, the water spaces must be scaled, for, however careful the engineer may be, a slight film of salt will be found which, if not removed, will of course increase in thickness, until it becomes a *crust*, and all the benefit of careful attendance lost.

If the ship enters a river of *fresh* water, the boilers should be filled with it, and it is advisable to *take time* to do so, contriving, if practicable, to choose about half-ebb tide for the operation. The specific gravity of the water must be observed, and a remark entered in the log. The *temperatures* of the brine and feed must both be taken by the thermometer, the former when it is boiled over the galley fire or on some ashes in the stoke hole. Sea water contains 3·00 parts of salt, and boils at 213 degrees of Fahrenheit. The temperature of the hot well will give that of the feed water. But if there be heating tubes, it must be taken from a cock between them and the boilers.

The observations at noon should be taken by the senior engineer himself every day. Those relating to the ship and the state of the weather can be copied from the ship's log, modified or further explained as may be thought useful. Let nothing be neglected that can in any way be serviceable.

The course and distance by observation at noon will give the speed of the ship. By taking the revolutions of the paddle wheels by counter, the ratio between the two velocities can be ascertained; and if there be no counter, an average of the strokes taken by the glass will be a close approximation.

It is of importance that the *force* and *direction* of the wind and sea in the morning and afternoon be carefully noticed and entered in the log, since every change will exert an influence over the steaming powers of the ship, which, if not accounted for, might lead to error in the data collected from the log. The names and numbers of the sails set should, under the same circumstances of immersion, &c., correspond with the degree of expansive working.

Remains of Coal—Is the total quantity on board after deducting the day's expenditure, and about 5 cwt. for the galley-fire. The remains of the day before is placed opposite the words *Brought over*. The expenditure of the last twenty-four hours is then noted, and the difference of these sums is placed opposite *Remains*.

The caution before given may be repeated: never trust entirely to the remains given in the log book, but compare them frequently with the quantity on board, by actual measurement, noting down as a remark any difference that may be found.

Remains of Tallow and Oil.—Note down the remain as for coal; weigh and measure out each day at noon enough of both for twenty-four hours consumption. As a guide, the quantity of tallow for a pair of beam engines of 420-horse power ought not to be more than 14 lb., and of oil 4 gallons. The tallow used for the inside of the boilers must be noticed separately; also all oil supplied for lamps, &c., out of the engine room marked *For ship's use*.

ENGINEER'S LOG. *Steam Ship.*

Hours.	Height of Steam.	Deg. of Expansion.	No. of Revolutions.	Coals consumed during Watch.			Height of Condenser Barometer.		Injection in Square Inches.		Boilers. Specific Gravity of the Brine.				No. of … out …	
				Ton.	*Cwt*	*Qrs.*	*Starb.*	*Larb*	*Starb.*	*Larb.*	1	2	3	4	1	2
A. M. 1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																

Temperature of Sea Water
,, of Condenser
,, of Brine
,, of Feed
,, of Engine Room
,, of Cabin
Height of Common Barometer

Course and Distance.

WIND { Force A. M. / P. M.

No. and Description of Sail Set { A. M. / P. M.

	Tons.	Cwt.
COALS brought over		
,, Expended		
,, Remains		

TALLOW broug…
,, Expen…
,, Remai…

P. M. 1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																

No. of Inches blown out of Boilers.				Initials of Engineer on Watch.	REMARKS.
1	2	3	4		

ce A.M. P.M.	Direction { A.M. P.M.	Sea { A.M. P.M.
		No. of Hours under Steam „ Revol. by Counter

	Cwt.	Lbs.		Gals.	Pints.	
brought over			OIL brought over			Immersion of Ship { Fore Aft
Expended			„ Expended			
Remains			„ Remains			„ of Paddles

REMARKS ON LITTLEHAMPTON HARBOUR.

Littlehampton Harbour will furnish you with an example of the abortiveness of the policy of such a scheme as a rectangular extension. The west pier of that harbour was extended in the year 1802 beyond the east pier; but being extended rectangular with the coast, or a little to the westward, the beach, as a matter of course, was stopped in its travels, until it reached the south end of the angle, and then filled the harbour's mouth as usual.

Some time afterwards, the conservators of that harbour committed themselves by extending the east pier, as it stands to this day, 250 feet beyond the western works; at least the piers which guide the power of the backwater with matter in suspension, brought over the dicky-work seaward, form the bar. And, indeed, it is a complete stop to all sands and shingle at the harbour's mouth; in addition to the imprudent manner the water is allowed to expand at its entrance. For example, the volume of backwater, in returning and entering the original piers, is only 104 feet wide, at the end of the first extension 173 feet, and at the mouth, only 750 further, is 230 feet wide. This fact speaks for itself, and the proposed extension at Shoreham harbour can have no comparison.

The rule laid down by Mr. Jessop on Little-hampton harbour is of itself sufficient to account for the bar. In his report on that harbour, in the year 1806, he states thus:—

"There are two leading principles to be kept in view in the improvement of a bar harbour: first, the extension of the entrance into the sea, *so as to remove the bar into deeper water;* and secondly, so to confine and direct the channel through, *or over the bar*, as to make the entrance most safely accessible, and with the greatest depth.

"The attempts to do this hitherto have not been attended with the desired success, and it is not difficult to account for the failure.

"About the year 1790, or some time before, a low groin of pilework was extended from the western pier about fifty yards in length, and in time the shingle also backed this up and ran over it, until within these two years; this groin has been renewed and made higher than the highest tides, and this has hitherto retained the shingle, though it is for some length level with the top of it.

"From the mouth of the harbour, the channel took a southerly direction, and a bar was formed at no great distance from the mouth. The course which it took was not the most desirable, but it is probable that it was not much liable to the inconvenience of variation. However, the *desideratum of obtaining a more direct channel, and of removing the bar into deeper water*, gave birth to the project of extending a groin of low pilework from the eastern pier, and it has at different times been carried out to the length of 260 yards; this has had the effect of making a straight and good channel *for that length*, and has so far removed the bar. And for a few years after it was done, I am informed that the entrance over the bar was good. *Unfortunately it was not foreseen, that whilst it would form a bar, it had no permanent faculty of preserving a passage through it.* But in the present state of the harbour, the combined current, instead of acting with a condensed power on the bar, is spread in a sheet, extending from the bar to the western pier, and yet its feeble force, shunning the high beds of gravel which have been created, and are increasing at the bar, is sufficient to maintain two visible swashways to the westward of the harbour, which have sometimes been open channels, but cannot be made permanent under the present existing circumstances."

Here Mr. Jessop facilitates, through his recommendations, the formation of the bar, but wastes his valuable talents in removing it.

Subsequently the same principle is admitted, and even so late as the year 1839, by J. M. Rendel, Esq., C.E., who on the same harbour reports thus:—

"This harbour, like all others of its class, *is maintained by the power of the backwater*, which being sufficient to drive to sea the gravel and sand washed up at its mouth, keeps open a navigable channel. Such harbours are commonly called "Bar Harbours," being always attended with a bank, or bar, *at the point where the current of the backwater is lost in the sea, or destroyed by the tidal current of the coast.*

"It will be evident from this description of a bar harbour, *that its depth and general capacity are determined by the power of its backwater*, compared with the tendency of the sea to form shingle or sand banks at its mouth, and that harbours situated on a coast so encumbered with sand and shingle as the coasts of Hampshire, Sussex and Kent are, demand from their conservators the strictest vigilance to *maintain their ancient receptacles for tidal water.*"

If the doctrines above promulgated were agreeable to the laws that govern the motions of the tides, sand, and shingle on this as well as on other coasts, how do these gentlemen account for the fact, that all harbours without backwater, and mere receptacles for tides, are universally free from bars?

Bars will always form, in defiance of any mechanical contrivances, if there be sufficient velocity and quantity of backwater to carry matter in suspension in a direct angle, and in the face of a superior and stronger fluid.

Therefore my object is, not to extend the western pier for the sake of length of a barrier in retarding the beach in its progress along the coast, but to extend the west pier in the natural direction, overlapping the present east pier, and by the south pier to pass the shingle to the east groyne.—*Mr. Prichard's Report on Shoreham Harbour.*

FRENCH CENTRAL SOCIETY OF ARCHITECTS.

A new Architectural Society has just been established in Paris, under the name of "The Central Society of Architects," a copy of the rules and regulations of which has been forwarded to us. These appear to have been drawn up with great care, and to be the result of much experience, but at the late hour at which we received them, we can only glance at the more prominent points which they contain.

The object of the Society is declared to be, "to entertain (*s'occuper*) questions relating to the art, and its practice, and to jurisprudence and administration as connected with architecture, viewed principally with reference to the public and private interests which belong thereto." The Society will consist, in the first place, of any of the following classes of architects, under some restrictions, who shall signify their wish to join it: viz., The architects forming the architectural section in the Academie Royale des Beaux-arts; the architectural professors of the Ecole Royal; those who compose the "jury" of the school; titular and honorary members of the Conseil-général des bâtiments civils; persons who have filled the office of chief or assistants in public works executed for the crown or the government; or lastly, those who have carried away certain prizes at the Ecole Royal d'Architecture. All others are required to possess certain conditions of eligibility, the chief of which is, a good theoretical and practical knowledge of their art, evidenced by works actually performed. Architects who act as contractors cannot be admitted till they have ceased to do so for three years at least.

The number of members is limited to 500, which will be divided into resident and non-resident (in Paris); there will also be corresponding foreign members. The members resident in Paris and the vicinity will be divided into sections or committees, of 25 each, each of which will elect its own president, &c., and whose business will be entirely distinct from that of the other sections. There will be two general meetings, annually, of the Society for the transaction of the usual business. The officers of the Society will be, a president, two vice-presidents, a principal secretary, and two under-secretaries, one of whom will act as keeper of the records, and the other as treasurer: the duties of these officers are laid down with great precision. There will also be three censors, who will see to the due observance of the rules and regulations of the Society, the proper employment of its funds, &c., on which subjects they will make reports to the general council. The entrance fee is 20 francs, with an annual subscription of the same amount. Very precise rules are laid down for the conduct of discussions, the election of members, and every other description of business which can occupy the attention of the Society. As it is now only in course of formation, we can furnish no particulars respecting the actual mode of its working, but shall take an early opportunity of doing so, believing that societies of this kind, by concentrating the ideas and information of many persons, are of essential service to all the individuals who compose them, and tend to the advancement of the art itself.

PROFESSOR DONALDSON'S EXAMINATION OF THE STUDENTS IN ARCHITECTURE AT THE LONDON UNIVERSITY.

The courses of lectures on architecture at the University College of London were completed on Thursday 15th of June, on which occasion the Professor accompanied his class to see some lime kilns in the neighbourhood of London, the parts and uses of which he explained in detail in illustration of lectures already delivered on the subject. The whole party proceeded to the Houses of Parliament, which were also examined in company with Mr. Barry, who with great kindness and affability very minutely pointed out every thing most remarkable and best deserving attention. The course for the session 1842-43 consisted of fifty-three lectures. On Tuesday the 27th the pupils entered the class-room for examination for honours. In class A (Architecture as a Fine Art), from 9 to 12; in class B (Architecture as a Science) from 1 to 4. The following regulations were observed:

A series of questions for the class was privately printed, and a copy delivered to the student after he came into the examination room. The answers were written in the examination room, into which no book was allowed to be brought. The paper containing the answers was signed with a number, and the name of the student using it enclosed in a sealed envelope, inscribed with the number, was left before the day of examination at the college, to be opened at the distribution of prizes.

Besides the prizes in each of the classes, certificates of honour were awarded to all who have attained a certain amount of excellence previously fixed.

The same student might gain a prize or a certificate in every class.

No student who obtained a first prize in a former session is allowed to contend for a prize in the same class in a subsequent session. And no student who obtained a second prize in a former session is entitled to receive a similar prize in the same class.

There were twenty-six students in architecture, and eight in each class went into the class-room to try for the prizes.

QUESTIONS.

Architecture as a Fine Art.

1. Into how many orders has architecture been classified by the Greeks, Romans, and modern Italians?
2. State the leading essential parts common to every order.
3. Make a sketch of the first rude building, showing the origin of the principal features of an order and temple.
4. Describe the distinctive features of each order.
5. How did the antæ differ from the pilasters, and to which people were these features peculiar?
6. Name the parts of a Corinthian capital.
7. Draw the spiral of an Ionic volute with its diagram.
8. Specify the general proportions of each order.
9. Name some edifices in Greece, Rome and London, classified according to the orders.
10. State and define the classes of temples according to the arrangement of the plan.
11. Describe the styles of temples according to the intercolumniation.
12. Draw the plan of a peripteral hypethral temple, and put the names to the several parts.
10. What were the propyla of ancient buildings, and their leading features? State examples.
14. Name and describe the principal parts of a Greek theatre, and give a rough sketch of the plan; note whether the circular part be a semicircle, or whether it be more or less than a semicircle.
15. With what people did triumphal arches originate? how many classes were there of them, and what the peculiar features.
16. Describe the uses and proportions of an agora and forum, and of the buildings connected therewith; note to what people each was peculiar.
17. Describe the Coliseum and thermæ or baths of the Romans.
18. Sketch a plan of a circus: state to what people peculiar, the uses of the parts, and the corresponding edifice with the other ancient people.
19. State the distinctive difference between Greek and Roman architecture.
20. What is the name of the classic writer on architecture? and at what period did he live?

EGYPTIAN ARCHITECTURE.

21. What are the earliest specimens of Egyptian architecture?
22. Describe the principal parts, the uses and decorations.
23. State the chief accompaniments of an Egyptian temple outside the peribolus, their arrangement, proportions, and decorative embellishments.
24. Sketch the plan of an Egyptian temple, with its several precincts, courts, and halls.
25. Make a sketch of a propylon with its decorative accompaniments.
26. What object in nature did the Egyptians adopt as the prototype of their capitals? Sketch, in their general proportions, two or three examples of shafts and capitals.
27. Draw a plan and section of a pyramid, showing its galleries and chambers.
28. Name the situations and dimensions of any of the principal pyramids.
29. Describe generally the peculiar character of Egyptian architecture.

ARCHITECTURE AS A SCIENCE.

(*Course B.*) *First Year.*

1. State the number and names of the classes, into which may be divided the materials used in construction.
2. Describe the natural structure of a tree, and give a section of the trunk.
3. Name the leading varieties of timber trees.
4. State the principal countries and ports in Europe and America, whence timber is imported into this country.
5. What is the relative value for constructive purposes of European and American timber?
6. State the leading features of dry rot,—the causes, effects, and remedies.
7. Describe the different sorts of resistance which timber has to offer in construction.
8. What are the principal and different manners of placing a piece of timber so as to support or resist a force or weight, and their relative efficiency?
9. If a beam have one end fixed in a wall, and its fibres were wholly incompressible, what would be the effect of a load placed upon its other or projecting end?
10. What would be the effect of a load placed upon the projecting end of a beam with the like conditions, but with the fibres wholly inextensible or non-elastic?
11. Draw a simple king truss for a span of twenty feet, put the name to each piece of timber, describe its use, and indicate by arrows the course of the forces acting upon the truss, and the point of resolution of the forces.
12. Draw a queen truss with the like details.
13. Sketch the articulations of the timbers at the heads and feet of king and queen posts, ends of the beams and joints tor plates, ties and braces.
14. Sketch various sorts of scarfings, distinguishing those which are soundest.
15. Sketch the section of a Gothic collar roof; name the various timbers.
16. Describe the timbers of single-joisted floors, single-framed and double-framed floors.
17. Describe the system of Herr Laves and of Philibert de Lorme.
18. Describe the principle upon which centerings should be constructed, and where the straining piece should be.
19. Make a plan and elevation of the scaffolding for the Nelson Monument.
20. Describe the scaffoldings used for raising the obelisks at Rome and at Paris.
21. Describe the machinery employed for raising the last statue of Napoleon to the summit of the Colonne Vendôme.

LIMES, MORTARS, CEMENTS.

22. State the classes into which mortars or cements may be divided.
23. What are the leading distinctive features of the various classes of limestones?
24. State the basis, and also the component part which renders a lime hydraulic.
25. Are we to rely upon the physical or chemical features of a stone, in order to ascertain whether it will produce a good lime?
26. What is the test?
27. Describe the processes of calcination.
28. Make a plan and section of a kiln for each process.
29. Does a limestone gain or lose weight by calcination, and in what proportion?

30. What are the different modes and phenomena of slaking lime?
31. Is lime strengthened or weakened by the addition of other substances.
32. State how many classes of substance are used with lime to produce mortar, and their respective influences upon mortar.
33. Describe the features of good and bad mortar.
34. From what stone is plaster of Paris made? State its qualities, and whence procured.
35. How many qualities of plaster of Paris are there, and to what uses is each applied?
36. How, where, by whom, and when was the cement discovered usually called Roman cement?
37. What is the term by which the Professor recommends this cement to be designated?
38. What are the peculiar features of the cement stone, physically and chemically, and in what stratum found?
39. Does this stone exist in other countries; and where?
40. Is the cement weakened or strengthened by the addition of other substances?
41. How and for what purposes is it used?
42. How may the strength of cement be tested?

T. L. DONALDSON, *Professor.*

These questions embraced the leading subjects treated of during the lectures of this session.

The distribution of prizes took place on the 1st July: they were awarded as follows:—

Course A Prize, Normand's Parallel and 1st certificate, E. Dobson; 2nd certificate, Frederick Lett.

Course B Prize, Tredgold's Carpentry and 1st certificate, Joseph Croucher; 2nd certificate, E. Dobson; 3rd certificate, G. Judge.

STEAM NAVIGATION TO INDIA.

A RETURN of the TOTAL AMOUNT expended for STEAM NAVIGATION to *India*, by way of the *Red Sea*, in each of the last Four Years, towards which Parliament has granted £50,000 yearly.

	Cost of the Vessels employed (Block, Engines, Armament, and Equipment.)	Pay and Allowances of Officers and Crews, Fuel, Stores, Provisions, &c., deducting Amount of Passage money received.	TOTAL.
	£	£	£
Cost of the Vessels employed in this service in the Period embraced in the Order of the Honourable House, which were built previously to the Year 1838-39	133,919	. . .	133,919
1838-39	78,949	70,774	149,723
1839-40	39,776	81,460	121,236
1840-41	50,000 partly estimated	57,209	107,209
1841-42	. . .	71,734	71,734

STATEMENT of STEAM VESSELS employed in the STEAM COMMUNICATION with *India*.

NAME OF VESSEL.	TONNAGE.	HORSE POWER.
Atalanta . .	616 Tons	211 Horses
Hugh Lindsay .	411 —	160 —
Berenice. . .	664 —	230 —
Zenobia . . .	684 —	280 —
Victoria . . .	714 —	230 —
Cleopatra . .	770 —	220 —
Auckland . .	946 —	220 —
Semiramis . .	733 —	300 —

INSTITUTION OF CIVIL ENGINEERS.

Description of the American Engine "Philadelphia," made by Mr. Norris, of Philadelphia, North America, for the Birmingham and Gloucester Railway. By G. D. Bishopp; communicated by Captain W. S. Moorsom, Assoc. Inst. C. E.

THE engine described in the paper was made in the year 1840, and has been in regular work for upwards of two years as an assistant engine upon the Lickey inclined plane, which rises at an angle of 1 in 37½, and is 2 miles 4 chains long. Its construction is what is termed a "Bogie" engine, having a four-wheeled truck to support one end of the boiler, while the other end rests upon the driving wheels. It has outside cylinders, inclined so as to clear the bogie wheels, over which they are placed, and it has inside framing. The boiler is cylindrical, 9 feet long and 3 feet 4 inches diameter, of plates 3-8ths inch thick. The fire-box attached to it has three of its sides square, and the front semicircular, with a spherical dome on the top, and the area of the fire-grate about 10 square feet; it was originally constructed of iron, with water spaces 2½ inches wide, the crown being supported by stay bars in the usual manner, but it was destroyed in about eight months, and has been replaced by a copper fire-box, of plates 5-8ths inch thick, with a tube plate 7-8ths inch in thickness. The tubes are 94 in number, 8 ft. 11 in. long, and 2 in. diameter outside; they were originally of copper, but were replaced by brass tubes when the new fire-box was fixed. Midway between the two end plates, is a third plate through which the tubes pass, so as to serve as a support, and to prevent them from sinking in the middle. The total internal area of the tubes is 404 square feet. The chimney is 13¾ in. diameter internally, by 13 ft. 10 in. high from the rails, and has not any damper. The framing is entirely of wrought iron, with the axle guides, &c. forged upon it. The bogie frame is also of wrought iron; it is attached to the smoke-box by a centre pin, and is carried by two pair of wheels, 2 ft. 6 in. diameter, made of cast-iron, chilled, and without tires. The driving wheels are 4 feet diameter, also of cast-iron, but with wrought-iron tires; they are firmly fixed upon a straight axle, as the cylinders are outside. The cylinders are 12½ inches diameter inside, with a length of stroke of 20 inches. Minute dimensions are given of the steam passage and valves (the "lead" of which is 1-8th inch, and to the eduction pipe nearly 1-4th, the motion of the slide extending 1 1-32nd inch on either side of the centre line); the steam-chests, the regulator, the gearing, and feed-pumps, and all the other parts of the engine and connexions. The general summary of the work done (the details of which are in the archives of the Institution of Civil Engineers) shows that with a maximum load of eight waggons and twenty men, making a weight of 53½ tons behind the tender, the engine ascended the Lickey inclined plane at a speed of between eight and nine miles per hour. That with six waggons, or 39½ tons, the speed was between 10 and 11 miles per hour; that with five waggons, or 33 tons, the speed increased to between 12 and 15 miles per hour, and that, in assisting the ordinary trains, with seven passenger carriages, the usual speed has been 13½ miles per hour. There are three engines of this class kept at the Lickey inclined plane for assisting the trains in their ascent, but one is generally found sufficient for the daily service.

The communication is illustrated by seven drawings of the engine and its details of construction, which have been communicated through Captain W. S. Moorsom, Assoc. Inst. C. E.

Captain Moorsom, in answer to questions from members, explained that—

	Miles.	Chains.
The length of the Lickey incline, rising 1 in 37 4-10ths, was	2	4
The bank engine ran out from its house at the foot of the incline, at each trip, for a length of		14
And continued running at the head of the train after surmounting the incline, for about		23
Thus giving an actual length on the ascent of	2	41

And as the same distance was covered in returning, the length of each trip was rather more than 5 miles. This was exclusive of some occasional piloting and train trips, which were, however, included in the general statement of expenses. The account of the entire expense of the bank engine establishment was made up of—1°, The wages of the drivers and firemen; 2°, Cost of coke, oil, and tallow; 3°, Repairs, including wages and materials; 4°, Depreciation of stock, stated at the end of each half-year; 5, General charges, comprising wages of pumpers, cokemen, cleaners and labourers; cost of firewood, hose-pipes, cotton waste, and all other stores; salaries of superintendents, clerks, foremen, time-keepers, and store-keepers; and the premium paid to the men for saving the coke. The cost of working the incline plane was therefore, for each half-year, ending—

—	31st December, 1841.	30th June, 1842.	31st December, 1842.
	£ s. d.	£ s. d.	£ s. d.
Wages . .	132 7 11	95 9 10	117 14 8
Coke . .	324 13 6	191 11 4	165 19 0
Oil and Tallow	49 8 4	27 1 7	17 18 6
Repairs .	245 1 0	260 3 8	92 6 11
General Charges	237 19 7	93 15 7	76 6 11
	989 10 4	668 2 0	470 6 0
Depreciation of Stock . .	99 0 0	Nil, having been improved.	89 16 0
Total .	1,088 10 4	668 2 0	560 2 0
Trips run . .	1,242	1,276	1,320
Miles run . .	6,210	6,380	6,600
Cost per mile run, 1st, Exclusive of Depreciation .	s. d. 3 2¼	s. d. 2 1	s. d. 1 5
2nd, Including Depreciation .	3 6	0 0	1 8¼

The engines had been improved by the alterations made since their arrival in England. These changes chiefly consisted in suppressing the tender, and placing the receptacle for water and coke upon the boiler of the engine, and in using the waste steam to heat the water; these had increased the efficiency of the machine, and caused a considerable economy of fuel. All the other changes were of minor importance, and had been chiefly suggested by the exigencies of the peculiar locality where the engine worked. The ecomical working of the engine was due partly to the attention and skill of the driver, who had become better acquainted with the capabilities of the machine, had a better knowledge of the locality, and was stimulated by a premium upon the saving of coke and other stores consumed, but was principally to be attributed to the judicious alterations that had been made in the construction. There had not been any reduction of the men's wages. The usual pressure of steam was between 60 lb. and 66 lb. per square inch. The weights of the trains varied considerably; they rarely consisted of less than three carriages; the heaviest he remembered weighed 98 tons, exclusive of the weight of the two engines, which were employed to convey it up the incline. He had not made any accurate experiments as to the amount of slipping of the wheels upon the rails, but with the ordinary traffic, he did not believe that any practical loss was occasioned by it.

Mr. M'Connell stated that the pressure of steam in the boiler of the American engine, when the experiments were tried, was more than 70 lb. per square inch; the spring balance was screwed down to 65 lb. pressure, and as, owing to the reduced speed of the engines, the steam was generated faster than it could be consumed by the cylinders, and thrown off by the safety valves, the pressure continued increasing. It should be understood that Bury's engine, alluded to in the experiments, was intended rather for conveying trains at higher velocities, than for mounting the incline with a heavy load; it was therefore labouring under a disadvantage. The steam ports in the American engine were very large, and although steam was thereby wasted, that arrangement was of material assistance, in the peculiar duty for which the machine was intended.

Mr. Braithwaite observed, that the quantity of coke consumed appeared to exceed materially that upon other railways; he understood that an engine recently constructed by Messrs. Rennie used about 18 lb. per mile, and that on the Liverpool and Manchester line, the average consumption was 16 lb. per mile. It appeared to him that the real questions were, the absolute duty performed with a given quantity of fuel, and at what cost? and also whether the greater adhesion of the driving wheels was due to the weight imposed upon the engine, by fixing the water tank upon the boiler, and the coke boxes upon the foot-plate, after suppressing the tender.

Mr. M'Connell replied that the peculiar duty of these bank engines required the steam to be kept up for about sixteen hours daily, during which period they made eight trips, amounting in the whole to about 40 miles, of which, during 20 miles only actual duty was performed, so that the greater portion of the coke was consumed while the engines were at rest. When they were running with luggage trains on the line the quantity of coke consumed was very small. The difference of cost, in consequence of the various alterations, and the improved mode of working the engine, was very great. In January 1842, the cost per trip on the incline was 17*s.* 5*d.*, but in January 1843 it only amounted to 7*s.* 1½*d.* The average weight of the luggage trains was about 60 tons; two assistant engines were used for heavy trains, merely as a precaution, in case of the wheels slipping; otherwise one of the "Bogie" engines could perform the duty alone, as with the passenger trains, which were always conveyed up by the bank engine alone.

Captain Moorsom said that the main question arising from this investigation was, by what system steep gradients could be worked, with the greatest efficiency, security, and economy; he would, however, in the present case suppose the two former positions to be equal in both cases, and would inquire only into the economy. It appeared from the returns of the London and Birmingham Railway Company, that the annual cost of working the Euston Square incline plane, which was 1 and 1-eighth mile long, with an average angle of 1 in 98, with stationary power and an endless rope, was—in 1840 £2,150, 1841 £1,376, 1842 £1,215 On the Edinburgh and Glasgow Railway, the expenditure upon the Glasgow incline, which was about one mile in length, at an inclination of 1 in 42, also with stationary power, was £1,516 in 1842. He had understood (but he could not produce authority for his statement) that, on the Great Western Railway, the cost of working the Box Tunnel incline alone, was, in 1841, about £3,500; and in 1842 it had been reduced to nearly £2,500; that was worked by locomotive power. Taking into consideration the number and weight of the trains, their speed, and the relative length and the angle of the inclines, he believed that the Euston Square incline might be said to perform about half as much work as that on the Lickey.

Mr. M'Connell presented drawings of the locomotive after being altered, of the detaching catch, and of the improved brake. After detailing some important alterations made by him in the valves, as well as the substitution of a different description of fire-bars and fire-frame, under an arrangement by which a considerable saving had been effected in the consumption of fuel, he stated that, for several reasons, but chiefly to increase the adhesion of the driving wheels of the engine, the tender had been suppressed, and a large tank constructed to be carried on the boiler of the engine. It was made of the best plate iron, ¼-inch thick; its length was 8 feet 9 inches, breadth 3 feet 5 inches, depth 3 feet at the sides, and 1 foot 11 inches at the centre; the bottom was made to fit the form of the boiler, and was bedded with a coating of thick felt: it was held in its place by four wrought-iron straps passing round the boiler. Advantage had been taken of the waste steam, by introducing a copper pipe from the top of the fire-box dome, into the upper part of the tank, carrying it, to and fro, from one end to the other, with an open extremity to allow the escape of the steam into the water; this pipe was furnished with a stop-cock; in addition to this a number of pipes were introduced from the smoke-box into the tank, by which arrangement the water in the tank was maintained at the boiling temperature, previous to being pumped into the boiler, which, in addition to the saving of fuel, proved advantageous in diminishing the leakage and breakage of the tubes and stays, arising from the sudden contraction by pumping in cold water, when the steam was shut off while descending the incline. The tank contained upwards of 400 gallons of water, a quantity sufficient for the engine over 18 miles, and goods' trains had been taken the whole length of the line (53 miles), by these engines with safety and economy. The supply of coke was carried in sheet-iron boxes, each containing about 40 lb. weight, and of a size to fit the fire-door of the boiler, ranged on platforms on each side of the foot-plate, which platforms were fitted with boxes, to hold the necessary tools required for the engines.

Mr. M'Connell then described a powerful and efficient description of brake, which he had constructed to act upon the driving wheels; it was so arranged that the whole weight of the fire-box end of the engine could be thrown on the wheel tires; one brake had been found quite sufficient to stop the engine on any part of the incline: from their position they were very easily brought into action; the end working upon the fore part of the wheel, was connected to a stud made fast to the framing of the engine; the other end was worked by a screw 1 and 3-8ths of an inch in diameter, passing through a bracket fixed on the boiler, which served as a nut. The main spring-plate of the brake was rendered flexible by the wood blocks being in short segments, thus enabling their entire surface to be brought into close contact with the periphery of the wheel. A new form of catch, employed for detaching the engine from the train, was described; it was stated to be managed with facility, and at the same time was perfectly secure. The principal advantages of these engines were, he believed, the economy in the consumption of fuel, and the increased adhesion of the driving wheels (the weight upon them being upwards of 10 tons, thus rendering the engine more effective in drawing heavy loads). The expenses of repairs had also been much decreased by the improvements suggested by practice. The following statement showed the comparative consumption of coke at different periods, viz.:—

For six months ending	June,	1841,	92·41 lb. of coke per mile run.
"	January,	1842,	86 "
"	June,	1842,	53·35 "
"	January,	1843,	43·2 "

On the Causes of the unexpected Breakages of the Journals of Axles; and on the means of preventing such Accidents by observing the Laws of Continuity in their Construction. By William John Macquorn Rankine, Assoc. Inst. C. E.

The paper commences by stating, that the unexpected fracture of originally good axles, after running for several years, without any appearance of unsoundness, must be caused by a gradual deterioration in the course of working; that with respect to the nature and cause of this deterioration, nothing but hypotheses have hitherto been given; the most accepted reason being, that the fibrous texture of malleable iron assumes gradually a crystallized structure, which being weaker in a longitudinal direction, gives way under a shock that the same iron when in its fibrous state would have sustained without injury. The author contends that it is difficult to prove that an axle which, when broken, shall be found of a crystallized texture, may not have been so originally at the point of fracture, although at other parts the texture may have been fibrous. He then proceeds to show that a gradual deterioration takes place in axles without their losing the fibrous texture, and that it does not arise from the cause to which it is usually attributed. From among a large collection of faggotted axles which had broken after running between two and four years, five specimens were selected, of which drawings are given, representing the exact appearance of the metal at the point of fracture, which in each case occurred at the re-entering angle, where the journal joined the body. The fractures appear to have commenced with a smooth, regularly-formed, minute fissure, extending all round the neck of the journal, and penetrating on an average to a depth of half an inch. They would appear to have gradually penetrated from the surface toward the centre, in such a manner that the broken end of the journal was convex, and necessarily the body of the axle was concave, until the thickness of sound iron in the centre became insufficient to support the shocks to which it was exposed. In all the specimens the iron remained fibrous; proving that no material change had taken place in its structure. The author then proceeds to argue, that the breaking of these axles was owing to a tendency of the abrupt change in thickness where the journal met the shoulder, to increase the effects of shocks at that point; that owing to the method of manufacture the fibres did not follow the surface of the shoulder, but that they penetrated straight into the body of the axle; that the power of a fibre to resist a shock being in the compound ratio of its strength and extensibility, that portion of it which is within the mass of the body of the axle will have less elasticity than that in the journal, and it is probable that the fibres give way at the shoulder on account of their elastic play being suddenly arrested at that point. This he contends would account for the direction of the fissure being inward towards the body of the axle, so that the surface of the fracture was always convex in that direction. It is therefore proposed, in manufacturing axles, to form the journals with a large curve in the shoulder, before going to the lathe, so that the fibre shall be continuous throughout; the increased action at the shoulder would thus be made efficient in adding strength to the fibres without impeding their elasticity. Several axles having one end manufactured in this manner, and the other by the ordinary method, were broken: the former resisted from five to eight blows of a hammer, while the latter were invariably broken by one blow. The vibratory action to which axles are subjected is considered, and it is contended, that at the place where there is an an abrupt change in the extent of the oscillation of the molecules of the iron, these molecules must necessarily be more easily torn asunder; and that in the improved form of journals, as the power of resisting shocks is increased by the continuity of the superficial fibres, so is the destructive action of the vibratory movement prevented by the continuity of form. The paper is illustrated by five drawings, showing the section of the journals of broken axles, and their appearance at the moment of fracture.

Mr. York agreed with Mr. Rankine in several points, and stated, that since the last meeting he had made a series of experiments, which confirmed his opinion relative to the vibration of solid railway axles being arrested, when the wheels were keyed on tight. In all such cases, where the vibration was checked, fracture would, he contended, be more likely to ensue, but with hollow axles there was very little difference of sound when struck, and no diminution of strength after keying on the wheels; this he attributed to the regular distribution of the molecules in the metal of the hollow cylinder.

Mr. Parkes coincided with Mr. York's opinion, and he believed that hollow axles would eventually supersede solid ones, particularly if they had sufficient rigidity for resisting flexure. Their facility of transmitting vibration more readily was in their favour; it was well understood that in pieces of ordnance and musket-barrels great regularity of proportion in the metal was requisite, in order to ensure the equal transmission of the vibration, caused by the sudden expansion of the metal at the moment of the explosion, and unless the vibration was regular the barrel would burst or the ball would not be correctly delivered.

Mr. Greener, of Newcastle, among other experiments, turned the outside of a musket-barrel to a correct taper, and fixed tight upon it at given intervals several rings of lead 2 inches in thickness: on firing a charge of 4 drachms of powder he found that all the rings were loosened and had all expanded regularly in their diameter. It was a well-known fact that cannon seldom or never burst from continuous firing; such accidents, unless they arose from peculiar circumstances, generally occurred in consequence either of inequality in the nature of the metal or irregularity in its distribution; to the latter cause must be attributed the bursting of the "Mortier monstre" before Antwerp, and of a large gun which was proved at Deal some time since; this latter gun burst at the third discharge, after delivering the ball better than on either of the previous discharges; it was evident that the fracture did not occur under the explosion of the powder, but on the re-entering of the air into the mouth of the gun after the discharge, and also because the thickness of metal was not well-proportioned, whereby the vibration was unduly checked, the cohesion of the molecules of the metal was destroyed, and the gun fell into several pieces, without any of them being projected, as they would have been by the usual effect of an explosive force. The most practical millwrights were well aware of the superiority of hollow shafts, and they were frequently used, as they were more easily kept cool than solid ones, especially at high velocities, when shafts were peculiarly liable to injury from percussive force or from a series of recurring vibrations.

Description of a Method of laying down Railway Curves on the Ground. By William John Macquorn Rankine, Assoc. Inst. C.E.

The method described in the paper depends on the well-known principle, that the angle subtended at any point of the circumference of a circle, by a given arc of that circle, is equal to half of the angle subtended at the centre by the same arc. The points which must be ascertained beforehand, are the same as in every other method of laying down curves, viz., the radius; the number of degrees, minutes, and seconds in the entire arc of the curve; and the length of the two equal tangents; either of which three quantities can be calculated from the other two. The commencement of the curve (A), its termination (B), and the intersection of the two tangents (D), are to be marked on the ground as usual. It is supposed that the centre line of the railway is marked by stakes driven at equal distances—say of 100 feet. Let (E) represent the last stake in the portion of the line immediately preceding the curve, the distance (AF) from the commencement of the curve to the first stake in it will be the difference between 100 feet and (EA). The angle at the circumference subtended by the arc (AF) must be calculated, and a delicate theodolite having been planted at (A), this angle is to be laid off from the tangent. The telescope will then point in the proper direction for the first stake in the curve, and its proper distance from (A) being set off by means of the chain, its position will be determined at once. The angles at the circumference subtended by (AF) + 100 feet, (AF) + 200 feet, (AF) + 300 feet, (AF) + 400 feet, &c., being also calculated, and laid off in succession, will respectively give the proper direction for the ensuing stakes (G), (H), (I), &c., which are at the same time to be placed successively at uniform distances of 100 feet, by means of the chain. It is scarcely necessary to observe, that the difference between an arc of 100 feet and its chord, on any curve which usually occurs on railways, is too small to cause any perceptible error in practice, even in a very long distance; but should curves occur of unusually short radii, it is easy to calculate the proper chord, and set it off from each stake to the next, instead of 100 feet, the length of the arc. When the inequalities of the ground prevent a distant view from any three stations to lay down the entire curve from them, any stake which has already been placed in a commanding position will answer as a station for the theodolite. By this method the operation of laying down a circular curve of any radius is made exactly analogous to that of laying down a straight line with the assistance of the telescopic sights of a theodolite. It is stated that by this method the curve is laid down with accuracy at the first operation; that any accidental error in the position of a single stake, affects that stake only; and it has been found in practice that the progressively increasing errors of the old method are entirely avoided.

Mr. Gravatt observed that a well-made theodolite was a convenient instrument for setting out curves for railways, and that it had been used by him and by his assistants for this purpose for several years. The common theodolite was not, however, in practice universally applicable without some further contrivances for accommodating it to this peculiar service. He stated that the circular arc (used, he believed, almost universally on railways) was not the true curve for a line of rails; as might be proved by considering that a straiht line of road required both rails to be at the same level, when viewed in the cross section, whilst on a curved road the outside rail required to be raised, in order to resist the tendency of the engine and carriages to fly off the rails in going round the curve.

Where a straight line was joined on to a circular arc, the before-mentioned condition would require an instantaneous and vertical rise of one of the rails, which was a condition that could not be fulfilled. In curves of contrary flexure, if composed of circular arcs, the difficulty was increased; for the outer rail, which ought to be the highest, suddenly became the inner and the lowest, so that an instantaneous elevation of one rail, and a corresponding depression of the other was required; if the curves were of the same radius, the alteration would be of double the extent to that required when passing on to the same arc from a straight line. Therefore, as the outside rail must be in all cases the highest, the circular arc, which required the manifestly false condition of an instantaneous elevation, could not be the true curve. He had several years since demonstrated that the true curve was one which commenced with an infinite radius, decreased in a regular manner, in advancing on the curve, when the radius might be constant for some time, and then increased again to infinity, before it joined either a straight line or another curve of contrary flexure. He had fixed upon the elastic curve, which complied with all the conditions required, but other curves were also applicable. His late assistant, Mr. W. Froud, had found that arcs of a cubic parabola, whilst they complied with the necessary conditions, were extremely convenient in practice: the equation and its fluxions, or differential co-efficients, being very simple and easy of application. Mr. Froude had also applied other properties of that curve, so that with the assistance of a few calculated tables, the process of setting out a a true curve was rendered as easy in practice as setting out a circular arc. With any curve there was considerable practical difficulty in finding the direction of the tangents, the radii of curvature, and the position of the curves upon the ground. Mr. Gravatt used what he termed a skeleton plan, of several stakes driven into the ground nearly in the course of the intended line, expressing their position by columns of figures with reference to two co ordinates; thus obtaining a numerical accuracy far greater than that of any drawn plan. By using a table of sines and co-sines, a few hours' calculation would save many days' labour in the field, besides ensuring an accuracy not otherwise to be obtained.

Description of Lieutenant D. Rankine's Spring Contractor. By Wm. John Macquorn Rankine, Assoc. Inst. C.E.

This paper describes a contrivance for suiting the action of the springs of railway carriages to variable loads, so as to give the proper ease of motion to a carriage when heavily laden, and at the same time to be sufficiently flexible for light loads. Its effect is to make the strength and stiffness of the spring increase in proportion to the load placed upon it. Each extremity of the spring, instead of supporting a shackle or roller, as in the usual construction, carries a small convex plate of cast iron. The form and position of this plate are so adjusted, that when the carriage is unloaded, it bears on the extreme end of the spring, thus allowing it to exert the greatest amount of flexibil ty; but as the plate is convex, the more the load increases, and the further the ends of the spring descend, the nearer does the point of bearing of the plate upon the spring, approach to the centre or fulcrum, so that the convex plate or contractor tends to diminish the virtual length of the spring in proportion to the load, the result of which is to increase the strength of the spring in the inverse ratio of its virtual length, and its stiffness in the inverse ratio of the cube of the same quantity. The author then gives, in a tabular form, the details and the results of some experiments made on springs of this description, which are similar to those now in use on the Edinburgh and Dalkeith railway. The springs were 4 feet long, each consisting of ten plates, each ¼ inch thick, and 2¾ inches broad. The contractors were cast with a radius of 12½ inches, and so constructed as not to act until the load on each spring exceeded 10 cwt., and with a load of 30 cwt. they should have contracted the distance between the bearing points to 3 feet 4 inches instead of 4 feet; by this means the strength of the spring was increased in the ratio of 6 to 5, and its stiffness in the ratio of 216 to 125. The advantages stated to be derived from the use of these springs on the Edinburgh and Dalkeith railway, and other lines, are,—that they afford the same ease of motion to a single passenger, as to forty or fifty in one carriage; they save wear both of carriages and railway track; they produce the strength and stiffness requisite for the maximum load with less weight of metal; they are not more expensive than rollers; and they are not offensive in appearance, indeed they would not be observed unless they were pointed out.

Results of the Application of Horse Power to raising Water from the Working Shafts at Saltwood Tunnel, on the South-Eastern Railway, in 1842. By Frederick William Simms, M. Inst. C.E.

This tunnel is driven in the middle bed of the lower green-sand, between which and the surface of the ground is interposed only the upper bed of the same stratum; but in sinking the eleven shafts for the work, it was found that at the level of the top of the tunnel the ground assumed the character of a quick sand, saturated with water, in such quantity that it could not be reduced by manual labour. Under these circumstances, horse gins were erected for drawing the water by barrels, containing one hundred gallons each, weighing when full about 1300 lb. The engineer's intention was to drive simultaneously from these shafts, in the direction of the tunnel, an adit or heading, to carry off the water; but the earth, which was sand mixed with fine particles of blue clay, was so filled with water as to become a mass of semi-fluid mud; great exertions were therefore necessary to overcome the water, without erecting pumps. At first this was accomplished by making each horse work for 12 hours, and then for 8 hours per day, allowing one hour for food and rest; as the water increased, it became necessary to work night and day, and the time of each horse's working was reduced generally to 6 hours, and sometimes to 3 hours. As all the horses were hired at the rate of seven shillings per day, the author, who had the direction of the works, ordered a daily register to be kept of the actual work done by each horse, for the double purpose of ascertaining whether they all performed their duty, and also hoping to collect a body of facts relative to horse power which might be useful hereafter. This detailed register, which was kept by Mr. P. N. Brockedon, is appended to the communication.

The author gives as a proposition, "That the proper estimate of horse power, would be that which measures the weight that a horse would draw up out of a well; the animal acting by a horizontal line of traction turned into the vertical direction by a simple pulley, whose friction should be reduced as much as possible." He states that the manner in which the work was performed necessarily approached very nearly to these conditions; and after giving the principal dimensions of the horse gins, he analyses each set of experiments, and by taking the mean of those against which no objections could be urged, he arrives at the following results:—

The Power of a Horse working for 8 hours = 23,412 lbs. raised 1 foot high in one minute; for 6 hours = 24,360 lbs.; for 4½ hours = 27,056 lbs.; for 3 hours = 32,943 lbs.

Of these results he thinks the experiments for 6 hours and for 3 hours alone should be adopted as practical guides, all the others being in some degree objectionable. As a means of comparison, the following table of estimates of horse power is given:—

Boulton and Watt, 33000 lbs. raised 1 foot high in a minute, by 8 hours work; Tredgold, 27,500 lbs., by 8 hours; Desagulier, 44,000 lbs., by 8 hours; Ditto, 27,500 lbs., hours not stated; Sauveur, 34,020, by 8 hours; Moore, for Society of Arts, 21,120 lbs., hours not stated; Smeaton, 22,000 lbs., hours not stated.

These are much higher results than the average of his experiments, and would more nearly accord with the extremes obtained by him; but under such excessive fatigue the horses were speedily exhausted, and died rapidly. Nearly one hundred horses were employed, they were of good quality, their average height was 15 hands ¼ inch, and their weight about 10½ cwts., and they cost from 20*l.* to 40*l.* each. They had as much corn as they could eat, and were well attended to.

The total quantity of work done by the horses, and its cost, was as under:—

		Tons.
Registered quantity of water drawn 104 feet, the average height, 28,220,800 gallons . . .	=	128,505
Ditto, ditto, earth, 3,500 yards, 1 ton 6 cwt. per yard .	=	4,550
Total weight drawn to the surface . .		133,055

Total cost of horse labour, including a boy to drive each horse, 1585*l.* 15*s.* 3*d.* Or, 2·85 pence per ton, the average height of 104 feet.

As soon as the adit was driven, all the water was carried off by it, and the works are stated to be perfectly dry.

DOUGLAS COAL-FIELD.

At the Ponfeig and Riggside Colliery, coal has been wrought from the most distant period; the coal here cropping out and lying level free. There is found here, 11 different seams of coal, varying in thickness from 9 to 3 feet, all workable seams, and extending to a depth of workable coal equal to 53 feet 2 inches; and it is supposed that under these seams is lying the excellent gas-coal now wrought at Lesmahagow. At Glespin Colliery there are known to be two seams, the first 5, and the second 6 feet 2 inches. There is every reason to believe that these seams lie above the former-mentioned 11 seams, thus making a depth of workable coal here equal to 64 feet 4 inches. At Brockley and Poniel Coal-works, there are four seams known, averaging from 6 to 3 feet, and extending to a depth of workable coal equal to 21 feet 7 inches. The greater part of this coal is of the finest quality, equal to the best household coal used in Glasgow. With the exception of gas-coal, none comes into Glasgow;

the cost of cartage, owing to its distance from the city, completely precluding it; nor will any, until this district be opened up by railway communication.

Limestone of excellent quality extends over the whole field. About 50,000 bolls are at present raised and sold annually from this district. Black-band ironstone has been found at the Poniel Coal-works, and has proved to be of excellent quality. There exist also several seams of clay-band ironstone. I have measured the area of this field, and find that it contains 16,492 imperial acres. This surface, according to the foregoing data, contains an average depth of workable coal equal to 15 yards; this will give a quantity of coal lying in this field, equal to 1,197,319,200 cubic yards; let one-third be deducted for stoops left in working the coal, and one-eighth for dykes and troubles, and what has already been wrought, and calculating the cubic yard to weigh 15 cwt. there will remain a quantity of coal that may be taken from this field amounting to 523,827,150 tons; which, at an annual consumption of 500,000 tons, will last for 1000 years. This field of coal is entirely neglected by the Deposited Lines of the Caledonian Railway; the Alternative Line passing to the opposite side of the Clyde, and leaving it altogether. By looking to the coal-fields on the east of the Clyde, it will be seen that they are already provided with both railway and canal communication. Were the supporters of the present Improved Line of the Caledonian Railway to make a Branch Line of Railway to Dundyvan, the line of railway to make would still be shorter than the Deposited Line by Hamilton, or the Alternative Line by Wishaw; and thus, the Caledonian Railway would have the full benefit of the coal-fields upon both the north and south sides of the Clyde. By this Improved Line there would also be a great local traffic in minerals going south. At the present time, the carriage of coals going south to Abbington, Crawford, Moffat, &c., is more than 10,000 tons annually. From these circumstances, it is my opinion that the mineral traffic alone that may be expected, would pay a very large per centage to the promoters of this Railway, without taking at all into consideration the great thorough-passenger traffic.

ROYAL COMMISSION OF FINE ARTS.

Her Majesty's Commissioners hereby give notice:—

1. That whereas various statues in bronze and in marble, of British sovereigns and illustrious personages, will be required for the decoration of the new palace at Westminster, artists are invited to send models to be exhibited for the purpose of assisting the Commissioners in the selection of sculptors to be employed.

2. The models are to be sent in the course of the first week in June, 1844, to a place of exhibition hereafter to be appointed.

3. The specimen or specimens, not exceeding two in number, to be sent by each artist, may be either prepared for the occasion, or selected from works already executed by him within five years prior to the date of this notice.

4. The works may be ideal or portrait statues, or groups, but not relievi. The subjects are left to the choice of the artists. The materials are to be such as are commonly used for models and casts. The dimensions are to be on a scale of an erect human figure, not less than three nor more than six feet.

5. The invitation to send works for the proposed exhibition is confined to British artists, including foreigners who may have resided ten years or upwards in the United Kingdom.

6. Artists who propose to exhibit are required to signify their intention to the secretary on or before the 15th of March, 1844.

By command of the Commissioners,

May 26. C. L. Eastlake, Secretary.

Whitehall, 16th June, 1843.

Her Majesty's Commissioners hereby give notice:—

1. That whereas carve-work in wood will be required for various parts of the New Palace at Westminster, and in the first instance for the doors of the House of Lords, artists are invited to send specimens in this department of art, to be exhibited for the purpose of assisting the Commissioners in the selection of persons to be employed.

2. The specimens are to be sent in the course of the first week in March, 1844, to a place of exhibition hereafter to be appointed.

3. The specimens are required to be designed in general accordance with the style of decoration adopted in the New Palace. Outlines in lithography, shewing the dimensions of the principal door of the House of Lords, may be obtained at the architect's offices in New Palace-yard.

4. Each exhibitor is required to send one and not more than two designs for an entire door, drawn to the scale adopted in the outline—viz. two inches to a foot; and one carved panel, or part of a panel and frame-work, not exceeding four feet in the longest dimensions representing a part of such design in the full proportion. The objects forming the details of decoration, in conformity with the conditions above expressed, are left to the choice of each artist. The material of the carved specimen is to be oak.

5. The invitation to send works for the proposed exhibition is confined to British artists, including foreigners who may have resided ten years or upwards in the United Kingdom.

6. Artists who propose to exhibit are required to signify their intention to the secretary on or before the 1st of January, 1844.

By command of the Commissioners,

C. L. Eastlake, Sec.

Whitehall, 16th June, 1843.

Her Majesty's Commissioners hereby give notice:—

1. That whereas various windows in the New Palace at Westminster will be decorated with stained glass, artists are invited to send specimens in this department of art, to be exhibited for the purpose of assisting the Commissioners in the selection of persons to be employed.

2. The specimens are to be sent in the course of the first week in March 1844, to a place of exhibition hereafter to be appointed.

3. The specimens are required to be designed in general accordance with the style of architecture and decoration adopted in the New Palace. Outlines in lithography, showing the dimensions of the windows, may be obtained at the architect's offices in New Palace-yard.

4. Each exhibitor is required to send one and not more than two coloured designs for an entire window, drawn to the scale adopted in the outline—viz. two inches to a foot; and one specimen of stained glass, not exceeding six feet in the longest dimensions, representing a part of such design in the full proportion. Such specimen of stained glass to be glazed up in lead, and framed in wood.

5. The objects forming the details of decoration may be either figures of heraldic devices relating to the royal families of England, or a union of the two, and be accompanied by borders, diapered grounds, legends, and similar enrichments.

6. The invitation to send specimens for the proposed exhibition is confined to British artists, including foreigners who may have resided ten years or upwards in the United Kingdom.

7. Artists who propose to exhibit are required to signify their intention to the secretary on or before the 1st of January, 1844.

By command of the Commissioners,

C. L. Eastlake, Sec.

THE "GREAT BRITAIN" IRON STEAM-SHIP.

This vessel was launched in the presence of Prince Albert the 19th July. The following is a general description of this gigantic steam-vessel:—Burden, 3500 tons; power, 1000 horse; length, from figure-head to taffrail, 322 feet; length of keel, 289 feet; extreme width, 50 feet 6 inches; depth of hold, 32 feet 6 inches. She has four decks: the first or upper deck is flush, and measures 308 feet in length. The second deck consists of two promenade saloons; the aft or first class is 110 feet 6 inches by 22 feet, and the forward or second class 67 feet by 21 feet 9 inches; they are well lighted and ventilated. The third deck consists of the dining saloons, the grand saloon being 98 feet 4 inches by 30 feet, and the second class or forward saloon 61 feet by 21 feet 9 inches. These saloons are all 8 feet 3 inches high, and surrounded with sleeping rooms, of which there are 26 with one bed, and 113 with two beds, giving 252 berths; these are, of course, the same height, and an improvement has been introduced which affords, by means of passages, much greater privacy than in any other vessel heretofore built; this is a great advantage. The fourth deck is appropriated to cargo, of which she can carry 1200 tons, besides coals, 1000 tons; underneath this deck, in the after-part of the ship, is an iron fresh-water tank, and in the fore-part is an air-chamber from the boiler to the fore bulk-head. The forecastle is appropriated to the officers and sailors; mess rooms, sleeping berths, sail rooms, &c., are underneath. The middle part of the vessel, from the bulkhead of the fore part to the bulkhead of the after part, a space of eighty feet, is occupied by the engines, boilers, engineers'-room, and cooking department, which is over the boilers. There are three boilers, capable of containing 200 tuns of water, heated by twenty-four fires, and four engines each of 250-horse power. The cylinders are eighty-eight inches in diameter, and the chimney is eight feet in diameter, and thirty-nine feet high. She has six masts, the highest of which is seventy-four feet above deck. She will carry about 1500 square yards of canvass, and will be rigged with Smith's wire rope, instead of ordinary rope. The hull is

divided into four water-tight bulkheads or compartments. Her consumption of coals will be about fifty tons per day. She will be propelled by the Archimedian screw, on the plan of the patentee, Mr. F. P. Smith. Upwards of 1500 tons of iron have been used in her construction, and that of the engines and boilers. Her draught of water when loaded will be about sixteen feet, and her displacement of water about 3000 tons. The plates of the keel are from three-quarters to one inch thick, and all the other plates are about one-half inch thick. She is clincker built, and double rivetted in the longitudinal laps. The ribs are framed of angle iron 6 inches by 3½. They are about fourteen inches apart in the middle, gradually increasing to eighteen and twenty-one inches, so that her sides are but seven inches thick. The boiler platform is of plate-iron, supported upon ten iron keelsons, the centre ones being 3 ft. 3 in. deep. At the engine-room, for the purpose of additional strength, there are 9 intermediate double ribs, and 16 additional transverse ribs. The joists for the support of the several decks, are bars of 3-inch angle iron with a joist bar of five inches by half an inch rivetted on the side. The distance of the joists about two feet and a half. The deck planks are fastened to the angle iron by screws from below, and firmly secured at each end to the vertical ribs, which affords a support to the sides, in resisting both external and internal pressure, and are supported lengthwise by longitudinal beams and stanchions. To preserve the hull from springing horizontally, there are diagonal tension bars placed between the angle iron bars and deck planks. The engines were constructed on the company's premises, under the superintendence of Mr. Brunel. Mr. Humphrys was the original resident engineer, but in consequence of the company refusing to adopt his patent trunk engines, he resigned, and shortly afterwards died. Since that period, Mr. S. R. Guppy, one of the directors, has acted as resident engineer. One principal peculiarity is that the cylinders will stand at an angle of about 60 degrees towards each other. One of the most remarkable parts of the machinery is the wrought-iron mainshaft, manufactured at the Mersey Iron-Works. This is the largest shaft ever constructed, weighing about sixteen tons. Her pumps will be worked by machinery, and will be capable of throwing off 7000 gallons per minute. The original estimate of the cost of the "Great Britain" was £76,000, but the cost will ultimately be from £90,000 to £100,000. The Great Western cost about £65,000.

MISCELLANEOUS.

Artesian Well at Woolmanhill.—The greatest of these interesting works yet existing in Aberdeen has just been successfully completed, at the tape-works of Messrs. Milne, Low, and Co., Woolmanhill. The bore is 8 inches in diameter, and 250 feet 9 inches deep. It required nearly eleven months' working to complete the excavation. In its progress, the following strata were cut through in succession:

Ft.	In.	
6	0	Vegetable mould.
18	0	Grey or bluish clay.
20	0	Sand and shingle, enclosing rolled stones of various sizes.
6	0	Light blue clay.
3	0	Rough sand and shingle.
115	0	Old red sandstone conglomerate—composed of red clay, quartz, mica, and rolled stones.
74	0	Alternating strata—of compact fine-grained red sandstone, varying in thickness from 1 to 7 feet; and clay, varying from 6 inches to 12 feet thick.
8	9	Mica slate formation—the first two feet of which were chiefly a hard brown quartzose substance, containing iron, manganese, and carbonate of lime.

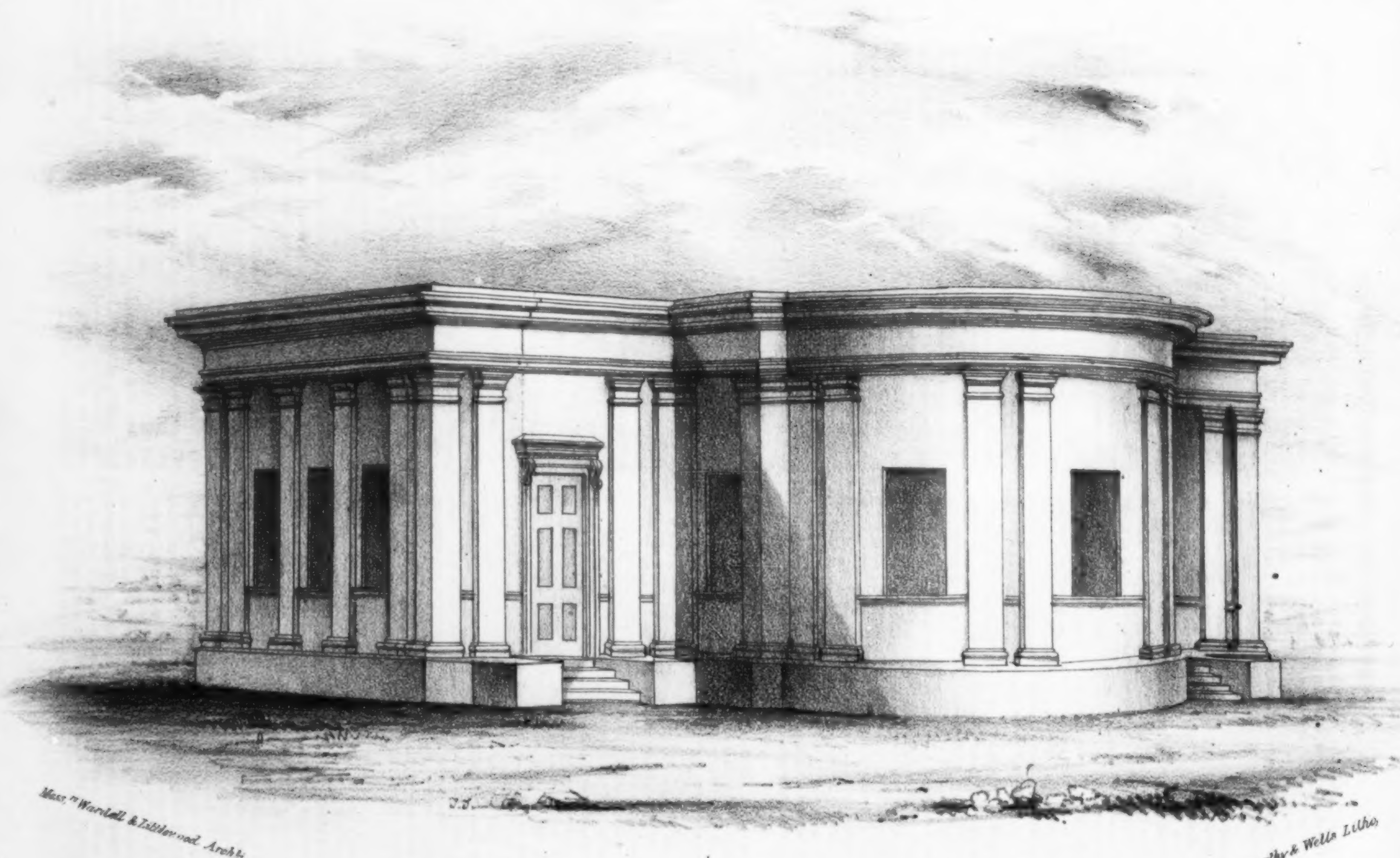
The temperature of the water at the bottom of the well, when completed, was found to be within a fraction of 50° Fahrenheit; and the average temperature of the locality, deduced from twenty-three years' observation, by the late George Innis, F.R.S., is 47° 1'; hence, nearly 3° of increase appear as the effect of central heat. The supply of water obtained is excellent in quality, and sufficient in quantity for all the purposes of the works. Such an opportunity of investigating the geology of the locality can but rarely occur; and, in the present instance, the proprietors and managers afforded every facility to scientific inquiries for conducting examinations. To make the bearings of the case clear and simple, the following is quoted from Mr. Miller's celebrated work on the old red sandstone (p. 22). In reference to this part of Scotland, he says: "The interior is composed of what, after the elder geologists, I shall term primary rocks—porphyries, granites, gneisses, and micaceous schists; and this central nucleus, as it now exists, seems set in a sandstone frame. The southern bar of the frame is still entire; it stretches along the Grampians, from Stonehaven to the Frith of Clyde. The northern bar is also well nigh entire; it runs, unbroken, along the whole nothern coast of Caithness, and studs, in three several localities, the northern coast of Sutherland, leaving branches of no very considerable extent between. On the east, there are considerable gaps, as along the shores of Aberdeenshire; the sandstone, however, appears at Gamrie, in the county of Banff."

The talented author will be glad to learn that, though the convulsions of nature have shattered the "frame" along the shores of Aberdeenshire, yet the fragments are not lost, as will be seen from the section above described; they are here reposing *in situ*, under the accumulated *debris* of uncounted ages, chiefly the boulder clay and sedimentary deposits of the Dee and Don, during a period when they mingled their waters in the basin in which Aberdeen now stands. The primary rocks—the settings—our granite of matchless beauty, stand out in bold relief a mile or two westward from the sea coast. Within this year or two, the old bed has been discovered at Davanha, Union Grove, Huntly-street, Glenburnie, Balgownie, and various other localities to the northward; hence, it may reasonably be inferred that our fragment of the frame envelops the primary rocks under our city and along the coast for a considerable distance between the Dee and Buchan-ness.—*Aberdeen Herald.*

The New Graving Dock at Woolwich.—This stupendous work, which has taken seven years in completing, was entered for the first time on Tuesday last, by her Majesty's frigate, *Chichester*. This magnificent basin is 300 feet long at top by 80 feet wide, tapering to 245 feet at bottom, and about 26 feet deep. It is lined throughout with dressed granite, eighteen inches thick, every stone being joggled to its neighbour by pieces of Bangor slate, to prevent the sinking of any part of the work. The sides of the basin are formed with altars, or steps, to facilitate descent, and also offering firm holds for props to support a vessel on her keel. The engineering difficulties in the formation of this work have been great; the excavation was cut through a stratum of peat, and another of quicksand, from which flowed a continual stream of water, to the amount of 800 gallons per minute. The work has been executed by Messrs. Grissell and Peto, from the plans of Mr. Walker,—cost about £80,000.—*Mining Journal.*

The "Victoria and Albert."—A trial trip of the new Royal yacht was made on Wednesday the 19th, when she proved herself to be a first-rate sailer, and an excellent sea boat; her speed was calculated at fourteen miles per hour, and it is anticipated that, when she is all ataunt and in proper trim, her rate of sailing will be even greater; in performing the fourteen miles per hour, it must be understood, that this is her actual speed through the water, without reference to the tide. The engines were by Messrs. Maudslay, Sons, and Field, of Lambeth, and are of 400-horse power, 6-feet stoke, and constructed on the double cylinder principle, as patented by Mr. J. Maudslay and Mr. J. Field, members of that firm. The peculiar advantages of the double cylinder principle are—the getting an increase of power within a given space and weight, and with a connecting-rod fully as long as those on the side lever or beam principle. There are two boilers, not tubular ones, but with the double tier of flues, first introduced by Messrs. Maudslay in the *Great Western*, and which have proved so eminently successful. During her trip the supply of steam was so abundant, that it was allowed to blow off almost without intermission the whole day. The paddles are upon the feathering principle; they are 30 feet in diameter, and boards 10 feet 6 inches in length, and eighteen revolutions were made per minute. The trial was very satisfactory, both as regards the efficiency of the engines and the capabilities of the yacht herself. The machinery worked with the greatest ease, and had been so correctly fixed, that it did not require the slightest adjustment.

New Anemometer.—We have lately here had a trial of a new instrument, intended to show the probable causes of the winds. It consists of a thin piece of wood three or four inches long, freely balanced, as the needle of a mariner's compass, on a steel pivot, by means of an agate inserted in the wood. At one of the extremities, at about a third of the length, there is made a slit, in which are placed three or four magnets, about half an inch from each other. They are formed of bits of flattened watch-spring, from one to three inches in length. They are fixed perpendicularly to the horizon, and therefore free from all polarity. They all have their south pole above the bit of wood, and their north pole below it. These magnets act exactly as the directing finger of a weathercock, and show the direction of the wind. The instrument may furnish interesting instructions with respect to the connection between magnetism and electricity, on the probability that the variations of the winds are due to electric currents. What renders it of great importance is the fact, that these indications take place a quarter of an hour, and sometimes half an hour before the changes which occur in the winds, as those of the barometer do in the variations of the weather.—*Journal des Debats.*



THE RICHMOND INSTITUTION.